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SATURN S-II
PRODUCTION OPERATIONS TECHNIQUES

PRODUCTION WELDING

Volume III - Circumferential Welding

30 October 1970

Prepared by
Saturn S-II Production Operations

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ABSTRACT

THIS VOLUME IS SUBMITTED TO NASA AS PART OF THE EFFORT BY NORTH AMERICAN ROCKWELL'S SPACE DIVISION TO DOCUMENT SPECIAL SKILLS DEVELOPED DURING THE SATURN S-II PROGRAM. THIS EFFORT PROVIDES DOCUMENTS WHICH WILL ENABLE QUALIFIED PERSONNEL UNFAMILIAR WITH THE PROGRAM TO CARRY OUT EFFICIENT OPERATIONS IN FUTURE S-II PRODUCTION.

FOREWORD

This volume is submitted to the National Aeronautics and Space Administration as part of the effort by North American Rockwell Corporation's Space Division to document special skills developed during the Saturn S-II Program. This effort, performed under Contract NAS7-200, provides documents which will enable qualified personnel unfamiliar with the program to carry out efficient operations in future S-II production.

This is Volume III of S-II Production Welding, one of five volumes documenting production operations skills. The complete set includes:

S-II Production Welding (SD 70-559)

- Vol I - Bulkhead Welding
- Vol II - Cylinder Welding
- Vol III - Circumferential Welding

S-II Production Insulation (SD 70-558)

- Vol I - Polyurethane Foam Application
- Vol II - Honeycomb Supports, Cork, Fairings, and Foil Seal Installations.



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INTRODUCTION

The complexities of the Saturn S-II welding processes and procedures have required considerable development and refinement to establish a production capability which can consistently produce S-II welds within specification requirements. These critical processes and techniques are documented here to maximize efficiency and personnel performance during S-II follow-on or restart activities. The processes and procedures documented in these volumes are applicable only to aluminum alloys within the 2000 series.

Volume III defines the special processes and techniques established for the circumferential welding of the cylinder and bulkhead assemblies to complete the LO₂ and LH₂ tankage as shown in Figure 1. This volume is divided into 10 sections, plus an Appendix. They are:

1. General Description
2. LH₂ Forward Bulkhead to Cylinder 6
3. Cylinder 5 to Cylinder 4
4. Cylinder 4 to Cylinder 3
5. Cylinder 2 to Cylinder 1
6. Cylinder 1 to J Joint
7. Cylinder 6 to Cylinder 5
8. LO₂ Girth
9. Cylinder 3 to Cylinder 2
10. Weld Repair Techniques

The Appendixes are:

- A - Glossary
- B - Tooling List
- C - Specifications
- D - Supporting Documents
- E - Equipment



Figure 1. Saturn S-II Stage

1.0 GENERAL DESCRIPTION

This section covers the assemblies to be welded, the weld assembly sequence, the tooling approach, the weld equipment and process to be used, the personnel skills required, the weld preparation and cleaning processes, selected precautionary measures, and the verification panels required to verify equipment function.

1.1 ASSEMBLY SEQUENCE PLAN

1.1.1 Circumferential welding of nine assemblies is performed as shown in Figure 1-1. The assemblies are joined initially to provide four major assemblies: LH₂ forward bulkhead-Cylinder 6 assembly, Cylinders 3, 4, and 5 assembly, common bulkhead-Cylinders 1 and 2 assembly, and aft LO₂ bulkhead assembly. The LH₂ forward bulkhead-Cylinder 6 assembly is then circumferentially welded to the Cylinder 3, 4, and 5 assembly, and the common bulkhead-Cylinders 1 and 2 assembly is welded to the aft LO₂ bulkhead assembly, providing two welded assemblies.

1.1.2 These two assemblies are welded circumferentially at the Cylinder 3 to Cylinder 2 closeout joint to complete the LH₂ and LO₂ tank weld fabrication. The weld land thickness for each weld joint is shown in Table 1-1.

1.2 TOOLING APPROACH

1.2.1 Two basic tool concepts are employed for the circumferential weld operations:

- a. Stationary components - moving weld head
- b. Stationary weld head - moving components

1.2.2 The first of these two concepts is used in Stations 1B, 1, and 3. The weld fixture holds the components in a fixed, level position. A skate track is attached to the outer circumference by means of vacuum cups. The levelled skate track is used to scribe, trim, weld, and X-ray the weld joint. Typical welds employing this technique are the LO₂ girth weld, J-section weld, and the Cylinder 2 to Cylinder 3 closeout weld.

1.2.3 The second approach is used in Station 1A. The weld fixture has the capability of 360-degree rotation in either direction. The weld heads

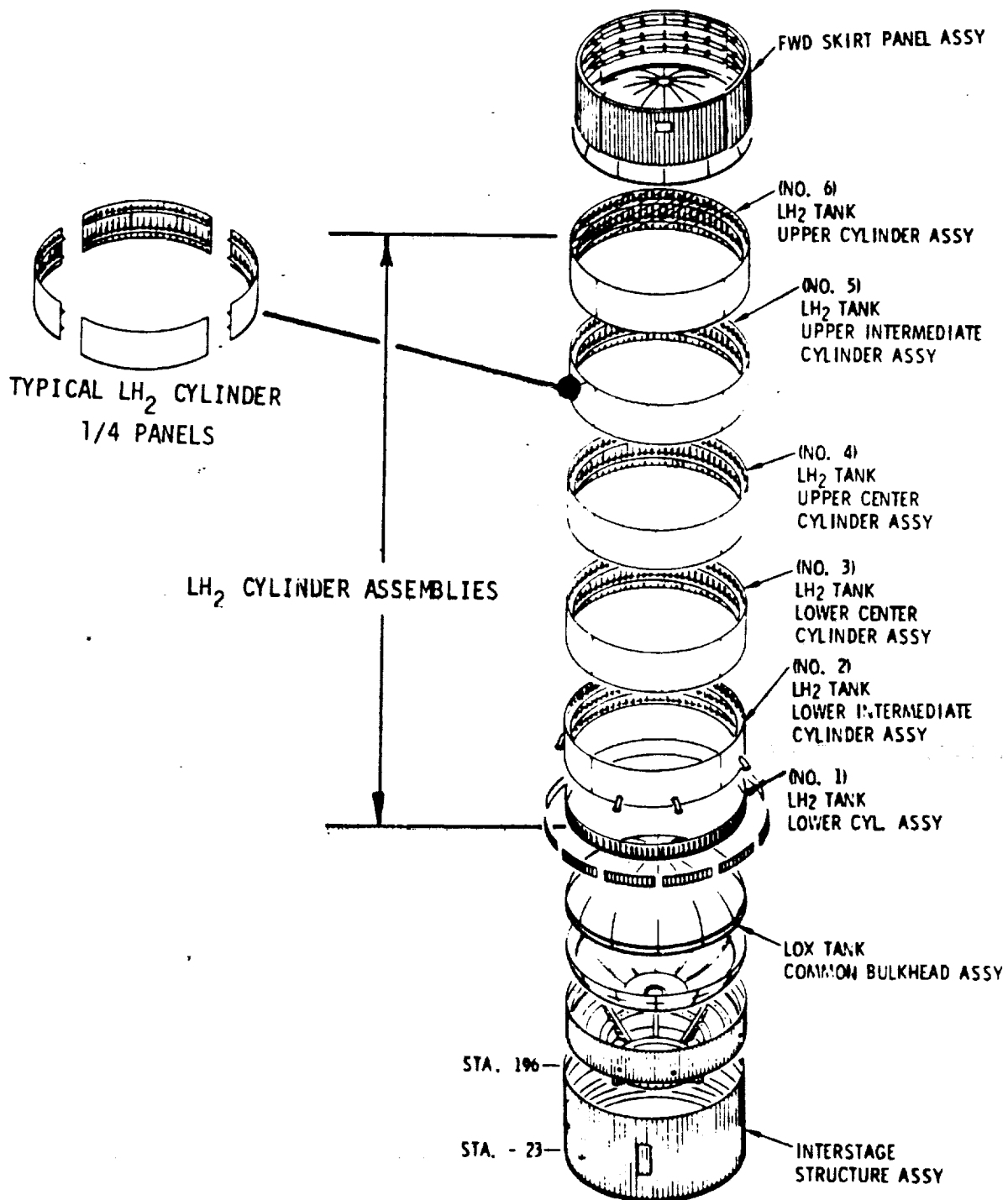


Figure 1-1. Tankage Weld Assemblies

Table 1-1. Circumferential Weld Lands

Circumferential Joint	Weld Land Thickness (in.)
LH ₂ Forward Bulkhead to Cylinder 6	0.290
Cylinder 6 to Cylinder 5	0.296
Cylinder 5 to Cylinder 4	0.296
Cylinder 4 to Cylinder 3	0.296
Cylinder 3 to Cylinder 2	0.296
Cylinder 2 to Cylinder 1	0.392
Cylinder 1 to J-Joint	0.256
LO ₂ Girth	0.550

are fixed in position 180 degrees apart and the components and weld fixture are rotated past the weld heads. Typical welds employing this technique are those joining Cylinder 4 to Cylinder 5 and Cylinder 6 to the LH₂ bulkhead.

1.3 CYLINDER 6 to LH₂ FORWARD BULKHEAD

1.3.1 Production tooling and welding equipment are provided in Station 1A. LH₂ Cylinder 6 is positioned and leveled on the turntable support fixture. The LH₂ bulkhead is moved above the cylinder and positioned on 12 saddle-block spacers installed on the upper edge of Cylinder 6. The cylinder is leveled by means of Teflon-protected adjustable screw jacks and verified with a dial indicator. The bulkhead is leveled with a set of vacuum chucks (upper and lower detail assemblies) which are installed on the inside of the subassembly. The bulkhead is trimmed with a skate saw mounted on a fixed vertical pedestal. The circumferential weld is accomplished as the turntable tool rotates the subassemblies past the two weld heads 180 degrees apart. Prior to welding, the circumferential sizing tool is installed on the inside of the subassembly. Equipment utilized includes two dc straight polarity, gas tungsten arc, fully automatic 600-amp welders.



1.4 CYLINDER 5 TO CYLINDER 4 TO CYLINDER 3; AND CYLINDER 2 TO CYLINDER 1

1.4.1 The same tooling approach is utilized as defined previously, except the trimming operation is not required. The circumferential welds are accomplished by welding Cylinder 5 to Cylinder 4 and then welding this assembly to Cylinder 3. To accomplish the circumferential weld for Cylinder 2 to Cylinder 1, special extension detail tooling is positioned on top of the turntable tool to elevate the top of Cylinder 1 to the level of the larger cylinders.

1.5 CYLINDER 1 TO J JOINT

1.5.1 Production tooling and welding equipment are provided in Station 1B, Manufacturing Aid Station, which is a movable building on tracks. The roof is removable for loading and unloading the subassemblies. The common bulkhead is loaded onto the tool with a 20-ton crane inside the VAB. The Cylinder 1-Cylinder 2 assembly is lowered and located on hydraulic jacks mounted on the tool's outer periphery. The jacks support the upper assembly and are individually operable for trimming the lower edge of Cylinder 1 and the upper surface of the J section. The skate saw is mounted on the tool's circumferential skate track by removing a track splice section. (This procedure is applicable when installing the weld machine heads.)

1.5.2 The upper assembly is hydraulically lowered to a specified dimension between the two assemblies to accomplish the welding procedures. Equipment utilized includes two dc straight polarity, gas tungsten arc, fully automatic, 600-amp welders.

1.6 CYLINDER 6 TO CYLINDER 5

1.6.1 Production tooling and welding equipment are provided in Station 1, Building S-03. The lower assembly (LH₂ Cylinders 3, 4, and 5) is positioned on the tool and leveled. The upper assembly (LH₂ forward bulkhead-Cylinder 6) is moved above the lower cylinder assembly and positioned on 12 saddle-block spacers, previously installed on the upper edge of Cylinder 5. The vacuum manifold system is positioned on the inboard side of the assembly to support the circumferential sizing tool.

1.6.2 The skate track tool is mounted to the outboard side of the lower assembly by vacuum pads. A splice section is removed from the track to install the weld machine heads and the splice is reinstalled.

1.6.3 The upper assembly is raised or lowered with the station overhead crane. The saddle spacers are removed and the circumferential sizing

tool positioned. The upper assembly is lowered within a specified dimension between assemblies and the welding procedure starts. Equipment utilized includes two dc straight polarity, gas tungsten arc, fully automatic 400-amp welders.

1.7 LO₂ GIRTH WELD

1.7.1 Production tooling and welding equipment are provided in Station 3 in Building S-03. The aft LO₂ bulkhead is positioned and leveled on the tool fixture. The internal work platform and protective pads are lowered and positioned in the bulkhead assembly. The circumferential sizing tool and supporting tooling details are installed on the work platform. The vacuum manifold system is installed and connected to the circumferential sizing tool vacuum cup system.

1.7.2 The skate saw is mounted on the tool's circumferential skate track by removing a track splice section. (This procedure is applicable when installing the weld machine heads.) The common bulkhead assembly is lowered and positioned on jacks mounted on the tool's outer periphery. The jacks are individually operable for trimming the lower edge of the assembly. After the net trim operation, the upper assembly is lowered to a specified dimension between the two assemblies to accomplish the welding procedures. Equipment utilized includes two dc straight polarity, gas tungsten arc, fully automatic 600-amp welders.

1.8 CYLINDER 3 TO CYLINDER 2 CLOSEOUT

1.8.1 Production tooling and welding equipment are provided in Station 1 in Building S-03. Before moving the LO₂ tank-Cylinder 2 assembly to Station 1, the work platform tools (T-7204674 and T-7204234) are positioned by the station's overhead crane on the common bulkhead assembly. The common bulkhead assembly is moved from Station 3 and positioned on the tool fixture located in Station 1. The tool is leveled. The vacuum manifold is assembled around Cylinder 2 (inboard and outboard). The circumferential skate track is installed on the outboard sidewall of Cylinder 2 by means of vacuum cups. The weld machine heads are mounted on the skate track by removing a track splice section. The splice is reinstalled and the track is leveled. The lower vacuum chucks are positioned approximately 8 inches below net trim of Cylinder 2.

1.8.2 The upper assembly (LH₂ bulkhead and Cylinders 3, 4, 5, and 6) is moved and lowered with the station's overhead crane onto safety blocks positioned at each crossover weld joint. For safety precautions the overhead crane remains connected to the assembly until the penetration weld is completed.



1.8.3 The circumferential sizing tool is installed to the inboard side and positioned between Cylinders 2 and 3. With the use of the overhead crane the Cylinder 3 assembly is raised and the safety blocks are removed. The Cylinder 3 assembly is lowered to a specified dimension between the two assemblies to accomplish the welding operations. Equipment utilized includes two dc straight polarity, gas tungsten arc, fully automatic 600-amp welders.

1.9 CIRCUMFERENTIAL WELDING EQUIPMENT

1.9.1 The welding equipment utilized throughout the production welding of the Saturn S-II is automatic gas tungsten arc. With the exception of one circumferential welding station where the assembly rotates about two stationary weld head assemblies, the skate principle is fully employed.

1.9.2 This commonality in all welding operations on the Saturn S-II provides complete interchangeability of welding equipment where current limitations and arc voltage response rate permit. Specifically, all welding equipment has current capacity from 400 to 600 amps and uses reactor grade helium as the shielding gas. All start and stop sequences are automatically programmed, as well as the four major functions of arc voltage, current, skate travel speed, and wire feed speed.

1.9.3 Electrode configuration control is another parametric function which is of the utmost importance and regarded as essential in aiding precise control and repeatability of all established certifications. Adaptive controls built into the welding equipment serve specific purposes. The circumferential welding operation is free fall, with the weld operation performed horizontally. No chill tooling is used nor is the linear taper adaptive control required. However, since the cylinder segments being welded depend on chill from the parent material, penetration is controlled by means of an electromechanical, adaptive penetration control. This control overrides the preset current within the specification limit of plus or minus 5 percent to produce the necessary drop-through with no suckback or incomplete penetration. Visual observation and manual override aids the system in performing its function.

1.9.4 In summary, the equipment and related components used on the Saturn S-II Program are as follows:

- a. The brand names of equipment used are "Airco Sampak" and "Sciaky Zero Error."
- b. The process employed is direct current, straight polarity, gas tungsten arc, fully automatic.



- c. Current capacities range from 400 to 600 amps.
- d. The electrodes used are 2% thoriated tungsten 1/8 inch and 5/32 inch in diameter.
- e. The electrode configurations are precision machined and controlled per established certifications.
- f. The shielding gas employed is reactor grade helium.
- g. All weld head assemblies are skate-operated except those used in Station 1A. These also may be skate-operated.
- h. Linear taper controls are used where material thickness varies.
- i. The electromechanical penetration control or current override potentiometer is used to control penetration where no chill tooling is available.

1.10 EQUIPMENT MAINTENANCE

1.10.1 All welding equipment utilized on production hardware must be maintained to rigid standards governed by both the Welding Equipment Procurement Specification (SB-0-63-48) and Process Specification MA0107-016.

1.10.2 A preventive maintenance program, established and controlled by Plant Services, is exercised during the quarterly calibration effort. Component changes or replacements are recorded and a complete history of each weld pack is maintained through a configuration control procedure specifically developed to assure consistent reliability and repeatability.

1.10.3 Prior to any preproduction weld certification or verification, a calibration check must be conducted by Plant Services technicians to confirm the original calibration parameters. Any evidence of deviation must be rectified at this time.

1.10.4 In the event of major equipment malfunction during a welding operation, a calibration check again must be performed after the malfunction has been corrected. All changes of components and malfunction cause must be recorded in the individual equipment log as governed by Configuration Control.



1.10.5 During all production welding, a Plant Services technician is present to aid the weld engineer and inspector in monitoring the equipment operation.

1.10.6 All welding equipment is secured and covered when not in use to prevent damage during other operations.

1.11 PERSONNEL SKILLS

1.11.1 Production of defect-free weldments in 2000 series aluminum assemblies demands quality workmanship. To accomplish this, each member of the welding team accepts responsibility to perform his assigned task in a conscientious manner. Each member performs his job systematically with concern for detail and approaches each step in the weld preparation and welding process without deviation from the established procedures. The welding team is described in the following paragraphs.

1.11.2 The weld supervisor is responsible for directing the welding team and is capable of making judgments, in conjunction with the weld engineer, pertaining to the weld preparation and welding process. He demands attention to details and insists on conformance to specified procedures.

1.11.3 The weld engineer is responsible for technical direction and coordinating decisions with the welding supervisor. He understands the welding processes, equipment, and the principles which produce defect-free welds, and is capable of directing the entire weld preparation and welding process. He establishes and aids in directing step-by-step procedures and conformance to specifications.

1.11.4 The welder is responsible for setting up the weld equipment, verifying existence of adequate consumables, and operating the equipment to perform the welding operations. He is certified by the training department and is capable of coordinating the weld equipment maintenance with the weld engineer and the Maintenance department. He understands the necessity for attention to details and recognizes the importance of following an operational checkoff list which includes the applicable Weld Schedule.

1.11.5 The metal fitter is responsible, under the direction of the supervisor, for performing all tooling and part setup operations, conducting all the cleaning and weld preparation, and the joint offset manipulations during the welding process. He is trained and qualified by the supervisor in the weld joint material preparation processes and tool setup, and functions applying to welding operations. He exercises good workmanship and meticulous care in all weld preparation and operations.



1.12 WELD PREPARATION AND CLEANING OPERATIONS

1.12.1 The most important operation of the entire circumferential welding sequence is the cleaning which is accomplished prior to welding operations. While many of the operations are automatic or semi-automatic, cleaning is completely manual. No machines have been designed which are capable of exercising the care and judgment required to create perfect welds.

1.12.2 The weld stations are closed to all unauthorized personnel during the cleaning operations. All outside doors remain closed during the pre-clean and welding cycle and are not opened until the conclusion of welding. Where applicable, environmental control curtains are closed.

1.12.3 All cabinet tops, tooling, building support beams, fixtures, etc., are vacuum cleaned or dusted to reduce possible contaminants in the area. The weld station floors are wet-mopped to reduce contamination of the weldment. Mopping is performed on the shift prior to the start of the pre-cleaning operations.

1.12.4 The temperature and humidity are controlled. The minimum temperature is 76 F, and maximum humidity allowed is 50 percent. The Maintenance department is responsible for maintaining the environment. If the temperature and humidity cannot be held to the established limits for the duration of the cleaning operations, management must decide on a course of action before operations are continued. If the temperature, humidity, or cleanliness levels exceed tolerances during the final cleaning cycle, the entire cleaning operation must be repeated.

1.12.5 Sawing operations are not allowed in a weld station once the area is prepared for the weld precleaning operation.

1.12.6 Clean white nylon gloves are worn during all cleaning functions. This is to assure that no organic particles, including lint and fingerprints, contact the weld surface (Figure 1-2).

CAUTION

The weld surfaces must never be touched with bare hands.

The weld surface is the area for a minimum of 2 inches on each side of the weld centerline, on both the inboard and outboard faces of the material, and the butt faces of the mating components.



1.12.7 Acetone is used as a cleaning fluid on the weld surfaces to remove oils, grease, fingerprints, dirt, etc.

CAUTION

Acetone is extremely flammable and must be contained in approved 1/2- or 1-pint plastic bottles with lock spouts.

Bulk acetone is procured in approved 1- and 5-gallon safety cans and stored in special safety-approved cabinets. All containers must be properly labeled.

1.12.8 Clean cheesecloth is folded into a 4-inch, 16-layer pad and dampened with clean acetone. The weld surface must not be wet with acetone, nor the cheesecloth saturated. The weld surface is wiped with acetone-dampened cheesecloth. The cloth is folded over the butt surface so that the inboard and outboard surfaces, as well as the butt faces of the material, are wiped simultaneously. The surfaces are rubbed hard enough to remove tape residue, oils, dirt, fingerprints, etc. Cloths must be changed frequently so that contaminants are not smeared into the weld surfaces.

CAUTION

All soiled wiping cloths are placed into approved safety receptacles.

1.12.9 A 4-inch diameter by 1-inch wide Bear-Text wheel is chucked in an air motor (Figure 1-3).

CAUTION

Make certain that the arrow on the side of the Bear-Text wheel points in the direction of rotation by applying air to the motor (Figure 1-4).

The area polished with the Bear-Text wheel is 2 inches in each direction from the weld centerline on the inboard and outboard sides of the weld surface of the weld land for the full length of the weldment. Moderate pressure against the surface is used, moving the wheel in long strokes so that excessive material is not removed in localized areas (Figures 1-3 and 1-5). The area polished is visually checked to assure removal of all Chem-film deposit in the area. The butt faces of the joint are not polished with Bear-Text.

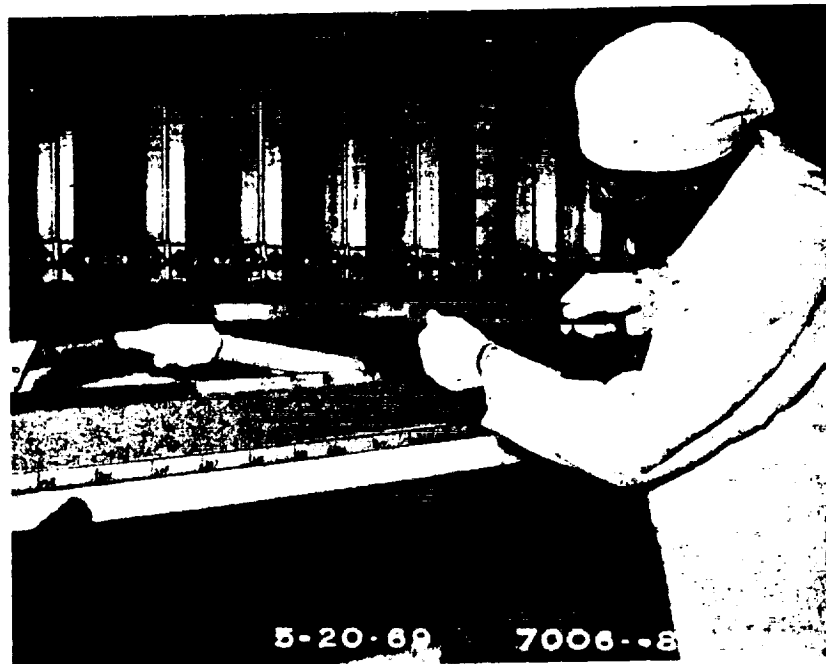


Figure 1-2. White Garment Operation (Precleaning)

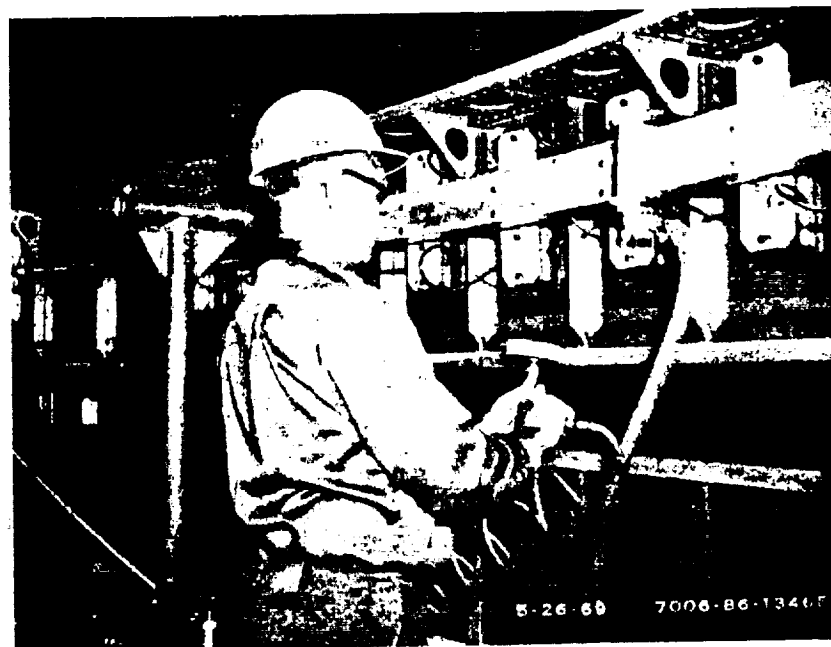


Figure 1-3. Use of Bear-Tex Wheel



Figure 1-4. Bear-Tex Wheel, Showing Direction Arrow



Figure 1-5. Use of Bear-Tex Wheel on Weld Land

CAUTION

All personnel in the immediate vicinity of the Bear-Tex polishing operation must wear eye protection.

1.12.10 Bear-Tex residue is wiped from the weld surface with a clean cheesecloth pad dampened with acetone. Cloths must be changed frequently and surface must be wiped until all residue is removed as shown in Figure 1-6.

1.12.11 The area around the weld surface and the adjacent tooling are vacuum-cleaned.

CAUTION

After the draw filing and scraping operations are started, acetone is not applied until all welding operations are complete.

1.13 PRELIMINARY FILING OPERATIONS

1.13.1 The cleaning operation is basically a draw-file operation. The filing is done using vixen files which have been cleaned in an acetone bath to remove all traces of oil, dirt, etc. Chips are brushed from the teeth of the file during use by a clean stainless steel brush which also has been cleaned with acetone and air dried. Plant air is not used to dry files and brushes after the cleaning process. They are allowed to dry in station atmosphere. Aluminum foil is acceptable for protecting clean files and brushes awaiting use. If contamination is detected during use, the wire brushes must be cleaned with acetone or discarded.

1.13.2 Only qualified, trained personnel may perform draw filing on the vehicle.

1.13.3 Material is removed by filing in one cutting direction only. Long strokes are used and the file is not dragged back across the cleaned surface during the return stroke. This causes small particles to become entrapped or ingrained in the base metal. The file is turned over at the end of each stroke. If the chips do not fall clear from the file teeth when the file is turned over, they must be brushed out with the stainless steel brush.

CAUTION

Failure to remove the chips may result in galling the weld surface. This is not acceptable.

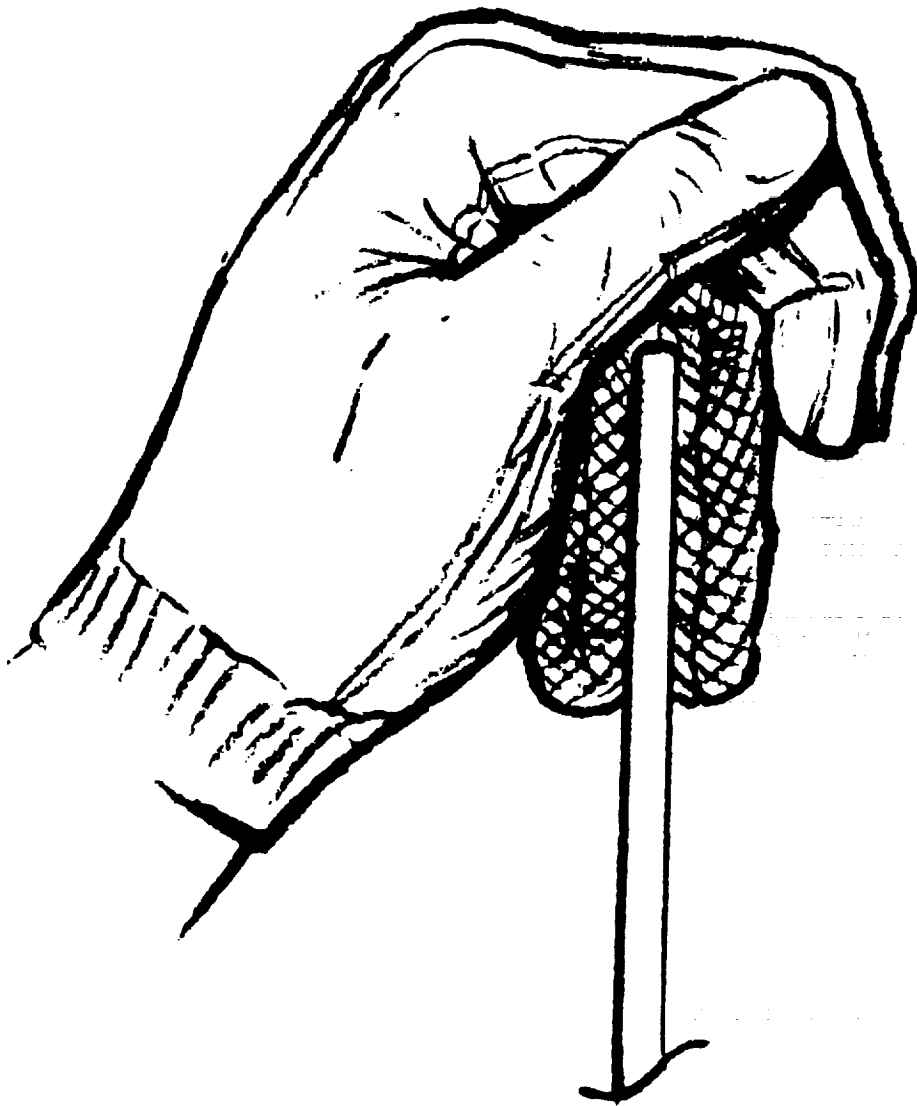


Figure 1-6. Wiping With Acetone-Dampened Cheesecloth



Chips or dust must not be blown from the metal surface with the breath or plant air as they will contaminate the metal. Chips are removed only by vacuum.

1.13.4 When filing the outer and inner faces of the weld joint the first two or three teeth on the end of the vixen file are used to scrape the surface (Figure 1-2).

1.13.5 Enough pressure is used on the file to assure cutting without leaving chatter marks which may pocket contaminates. Chatter marks are removed by a vixen file attached to a fender vixen handle. The file is lightly stroked flat against the surface. When the marks are removed, the surface is rescraped per the procedures described.

1.13.6 Filing continues until the machine tool marks, pits, and Chem-film are removed, and the surface is bright. Local areas that are difficult to clean with the file may be cleaned with an approved scraper, but the rule on cutting in one direction only still applies (see Figure 1-7).

1.13.7 The cleaned areas are visually inspected and local areas picked up with a file or three-cornered scraper. All chips are vacuum-cleaned from the area.

1.13.8 The butt faces of the mating parts are draw filed. In cleaning the butt faces the vixen file must lay flat on the surface. The file is pulled with enough pressure applied to remove material, easing pressure at the end of the stroke as shown in Figure 1-8. The file is not allowed to touch the surface on the return stroke. Long strokes are used, and the file is turned over at the end of each stroke.

CAUTION

If the chips do not clear the teeth of the file when the file is turned over, they must be brushed out with a clean stainless steel brush.

1.13.9 The inboard and outboard corners of the weld joint butt edges are beveled to a 45-degree angle by 1/32-inch minimum to 1/16-inch maximum. This operation, as in all filing operations, is in one direction only. Care must be exercised so that burrs and chatter marks are not produced.

CAUTION

Any burrs left on the bevel will burn-in the welding arc and cause oxides in the weldment which are not acceptable.

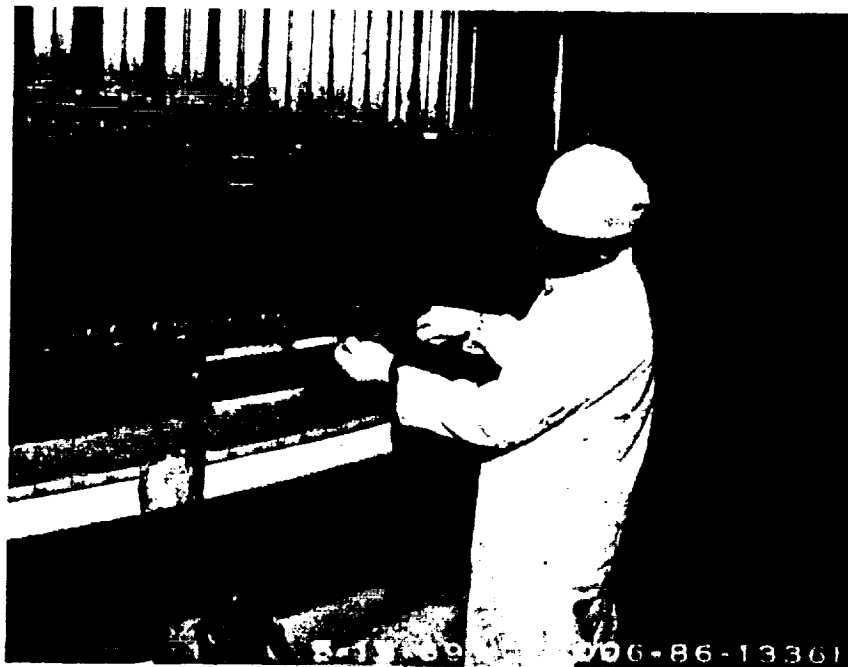


Figure 1-7. Draw-Filing Weld Land

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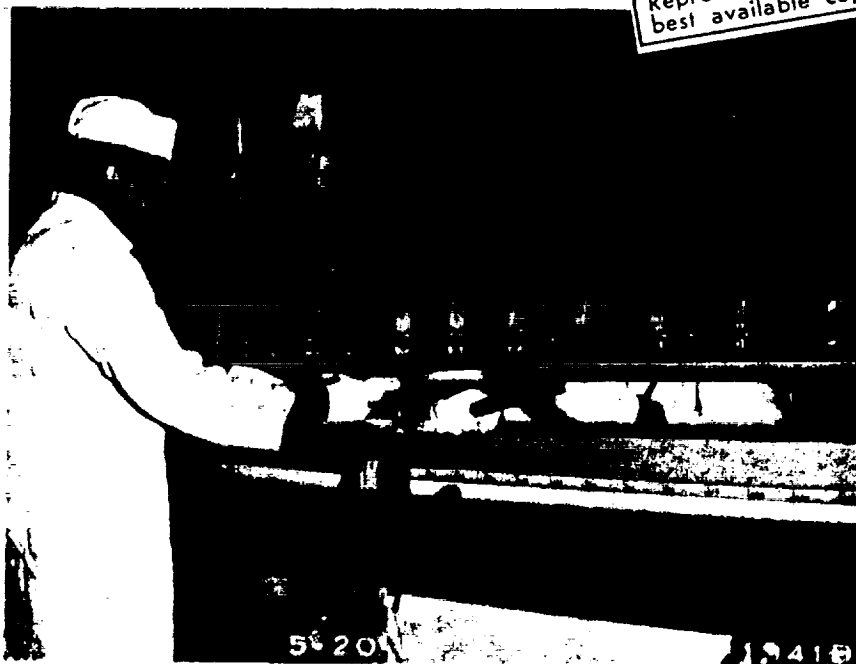


Figure 1-8. Draw-Filing Butt Face



All chips are vacuumed from weld surfaces, tooling, and floor.

1.13.10 The weld surfaces are visually inspected, using a mirror and a flashlight, for scratches, burrs, nicks, pits, etc. Any defects are removed by filing and vacuuming.

1.13.11 This completes the cleaning cycle. The steps for the final weld preparation and cleaning operation for tooling and weld cycles are discussed in the detailed procedures for each weld process.

1.14 VERIFICATION PANEL

1.14.1 Verification panels are prepared for each circumferential weld during tooling setup and prior to assembly weld operations to verify equipment calibration, equipment function, and weld parameters. Three panels are run prior to the precleaning operations; one from the first weld machine and two from the second. The maximum time allowed between verification panel welding and production welding is one week. The following operations are typical for all circumferential welds.

1.14.2 Two 4-foot by 6-inch panels of the same gauge as the circumferential weld to be made are precleaned. Cleaning is performed per the procedures previously detailed. If the welding is delayed, the cleaned edges of the panels are covered with aluminum foil.

1.14.3 During the precleaning operation, the test fixtures are vacuumed and the backing plates wiped with a cheesecloth pad moistened with acetone.

1.14.4 By means of the tooling clamps, one panel is fastened to the test fixture. The top edge of the panel is centered in the cutout of the backing plate.

CAUTION

The cleaned edge of the panel is not touched nor allowed to contact the tool.

1.14.5 The upper panel is positioned directly over the lower panel. A 0.040-inch gap is maintained between the panels while clamping the upper panel to the fixture. A precleaned 0.040-inch stainless steel shim is used if required at either end of the panels to maintain the gap during the clamping operation. The shims are removed just prior to tack welding.



1.14.6 During the loading operations the machine parameters are programmed by the welders and a clean spool of wire is inserted for use on verification panels and circumferential welds.

1.14.7 The ground and sensing leads from the machine are attached directly to the test plate, approximately 6 by 6 inches, which is clamped to the right-hand end of the test fixture.

1.14.8 The panels are blacklight inspected. Any contaminants which show up under fluorescence are removed by means of a vacuum hose. This operation is performed as the panels are mounted on the test fixture.

1.14.9 The weld parameters are programmed per the applicable 971-D Weld Schedule as defined in Specification MA0107-016. A bead-on plate is run for verification of equipment operation and the panels are tack-welded. The first tack is made at the right-hand end of the panels. The weld head is moved to the left, approximately 9 inches from the start of the first tack, and a 3-inch tack weld is run. Again, the head is backed up 9 inches from the second tack and a 3-inch tack weld is run. This back-stitching method prevents the panels from being drawn so tightly together that the offset cannot be controlled. Prior to each tack weld the offset is checked with a stainless steel gauge. If the offset is greater than 0.015 inch, the adjustment screws on the back side of the fixture are adjusted to move either panel until the desired offset target is met.

1.14.10 When the panels are tack welded, a continuous tack pass is run using parameters per the 971-D Weld Schedule. The continuous tack pass is wire brushed with a clean stainless steel brush and the panels are cooled for approximately 15 minutes. During this operation, the welder programs the parameters for the penetration pass per the weld schedule.

1.14.11 The penetration pass is run and allowed to cool. During the cooling period, the weld is again wire-brushed and the welding parameters are programmed for the cover pass.

1.14.12 When the test panel has cooled approximately 15 minutes, the cover pass is run. The panel is wire-brushed after the cover pass and visually checked for lack of fill. If any area does not meet the specification, a supplementary pass is run per the 971-D Weld Schedule.

1.14.13 The panel is removed from the test fixture and the cover pass and drop-through are milled to 0.010 inch \pm 0.010-inch high. The weld drop-through on the J joint-to-Cylinder 1 weld is not milled.



1.14.14 The weld is polished with a Bear-Text rotary wheel, using long strokes.

CAUTION

The Bear-Text wheel must not be stroked at angles to the direction of the weld bead.

1.14.15 The two verification panels are submitted to Quality Control for X-ray and fluorescent penetrant inspection. The panels must meet the inspection criteria or must be rerun. Upon approval of the verification panels, the precleaning operations on the vehicle are started.

1.15 PI-TAPE SIZING TECHNIQUE, LH₂ CYLINDERS

1.15.1 The diameter of the LH₂ cylinders is measured by using a steel tape called a pi-tape. The finished measurement of each cylinder is documented for use in mating the cylinders during circumferential welding operations.

1.15.2 A 33-foot-diameter steel pi-tape marked in 30-degree segments is used in conjunction with a 40- to 90-degree digital readout thermometer (386-E or equivalent), a 15- to 20-pound spring scale, and a 7X optical comparator. These instruments must be calibrated and verified periodically to assure their accuracy.

1.15.3 Manufacturing supervision is responsible for assigning and training production personnel for performance of this operation. A team of at least three persons is required. All members must be qualified in the use and care of all instruments and in the methods for obtaining the corrected dimensions. This team is the sole source of the pi-tape readings.

1.15.4 Manufacturing maintains a composite dimensional record of all pi-tape readings documented in the work orders for each vehicle.

1.15.5 The temperature of the part must be determined accurately in order to size the assembly properly. A one-degree change in temperature will increase or decrease the cylinder circumference by more than 0.015 inch. To determine the temperature, the digital readout thermometer is connected to the power source (Figure 1-9) and the switch turned on. Thirty minutes are allowed for warmup before readings are taken.

1.15.6 The pickup lead thermocouple is secured directly to the part by approved adhesive tape as close to the pi-tape as possible, but not on it. The pickup leads are connected to the digital readout thermometer. A stabilizing time of at least five minutes is allowed before taking a reading.

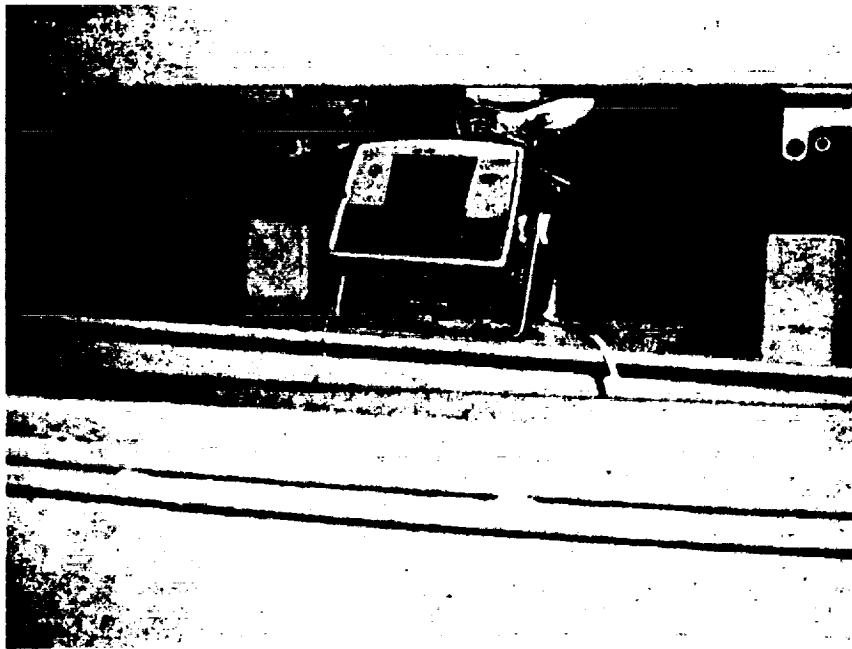


Figure 1-9. Digital Readout Thermometer

If there is fluctuation of the digital readout, an average of three readings is taken as the part temperature. The final reading is taken within 2 minutes of the time the pi-tape readings are taken.

1.15.7 The dimension is corrected for temperature using the values listed in the expansion/contraction charts. The correction figure is calculated by multiplying the change factor by the temperature difference between the existing part temperature and 68 F. If the part temperature is above 68 F, the correction figure is subtracted from the actual part dimension. If the temperature is below 68 F, the correction figure is added to the actual pi-tape reading (Table 1-1). The corrected dimension is the one which is used as the official part size and is recorded in the FAIR book.

Table 1-1. Expansion and Contraction Factor Chart

Degree of Arc (degrees)	Change Factor per ° F (inches)
90	0.0039
210	0.0092
270	0.0117
330	0.0144
360	0.0156



1.15.8 The most important operation for sizing the cylinder assemblies, other than possible calculation errors, is the care and method used to position the pi-tape on the part. Before positioning the pi-tape, the circumferential trim line on the part top and bottom is located and marked intermittently. The zero-degree mark on the tape is aligned with the start line on the part. The tape is secured to the part with a C clamp. The start line on the completed cylinder can be any predetermined point.

CAUTION

All degree alignment or tape readings are accomplished utilizing an optical comparator with a minimum magnification of 7X.

1.15.9 The edge of the tape is positioned to coincide with the horizontal trim line. A tension of 6 pounds is applied and maintained as the tape is positioned, using a 15- to 20-pound spring scale and adapter as shown in Figures 1-10 and 1-11. The scale is attached and tension is applied approximately 12 feet ahead of the last attach point (a lesser dimension as the end of the tape is approached). The tape is secured to the part with Mystic tape No. 7331 or 7300 at 2- to 3-foot intervals. The 360-degree end of the tape is secured with a C-clamp while the 6-pound tension is still being applied.

1.15.10 Each tape is identified with a calibration number assigned by the Metrology division. A calibration test report, furnished with each tape, gives the length from zero-degree to each of the 30-degree graduation marks throughout the 360-degree range. These dimensions represent the actual length of the tape at 68 F corrected.

1.15.11 The tape has vernier lines on either side of the 360-degree mark which represent 0.049-inch increments. These lines are used for determination of the 360-degree cylinder circumferential dimension before correction for temperature.

1.15.12 In measuring the full 360-degree circumference of a cylinder, the tape is positioned as in steps 1.15.8 and 1.15.9. If the zero-degree mark and the 360-degree mark are in alignment, the cylinder circumference is the same as the 360-degree dimension recorded in the calibration test report. If the zero-degree and 360-degree marks are not in alignment, it is necessary to use the 0.049-inch graduation marks on either side of the 360-degree mark to determine the actual size of the cylinder.

1.15.13 For example, if the 360-degree graduation is to the right of the zero-degree mark, the circumference is less than the tape size, and the amount is subtracted from the calibration test report figure for 360 degrees.



Figure 1-10. Positioning Pi-Tape to Horizontal Trim Line



Figure 1-11. Applying Tension to Pi-Tape



If the 360-degree graduation is to the left of the zero-degree mark, the circumference is larger than the tape and the amount is added to the calibration test report figure. Correction for temperature is obtained using the directions in steps 1.15.5 through 1.15.7.

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2.0 CYLINDER 6 TO LH₂ BULKHEAD WELD

2.1 GENERAL DESCRIPTION

2.1.1 The special techniques and procedures essential to a successful weld of Cylinder 6 to the LH₂ forward bulkhead in Station 1A of the bulkhead building are described in this section. The upper and lower cylinder circumferences, of Cylinder 6 are pretrimmed prior to loading in the weld station on the turntable (T-7204224). Rough and final trim of the LH₂ forward bulkhead is performed in the weld station with the bulkhead positioned above the cylinder assembly. The techniques and procedures developed for bulkhead trim and weld joining to Cylinder 6 are defined in the following paragraphs.

2.1.2 Reference documents applicable to this procedure are as follows:

V7-332002	LH ₂ Tank Assembly
V7-332141	LH ₂ Bulkhead Assembly
V7-332242	LH ₂ Tank Upper Cylinder Assembly (No. 6)
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-Film
971-D-00265	Weld Schedule
MHP-C-76-S-II	Install LH ₂ Bulkhead on LH ₂ Cylinder in Station 1A
MHP-C-87-S-II	Move LH ₂ Cylinder From Storage to Station 1A Using Pneumagrip
TOS-556-0005	Circumferential Sizing Tool
TOS-556-0008	Turntable - Circumferential Welding
TOS-556-0027	Offset Measuring Tool - Circumferential Welding
PRO-565-016	Circumferential Weld LH ₂ Bulkhead to Cylinder 6

2.2 LOADING THE STATION

2.2.1 LH₂ tank Cylinder 6 is 100 inches long. When loading it into weld Station 1A the guard rails and support pedestal (8EH-0852) must be removed from the second-level weld platform to gain clearance for positioning Cylinder 6 on the rotating pedestals. Next the utility-support crossarm and pedestal are disassembled. This is accomplished by removing the ball lock pins from the upper center of the crossarms and the 4 nuts from the pedestal. These parts are then stored neatly on the floor.



2.2.2 The cylinder is leveled to a uniform height above the turntable base using jack screws and straight edge at the Teflon pad on the weld tool. The cylinder is centered on the pads, using adjusting screws to move the cylinder inboard or outboard as required.

CAUTION

Handling and loading of Cylinder 6 is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has a responsibility to assure adherence to accepted safety practices. The move conductor must be in attendance during all phases of the move.

2.2.3 The cylinder is lowered to rest on the Teflon-protected screw jacks as shown in Figure 2-1. The cylinder is centered by adjusting the inboard and outboard Teflon-protected screws on the clevis of the support jacks (Figure 2-2). The space between the clevis and the cylinder wall is equalized by tightening or loosening the outboard and inboard screws.

CAUTION

Do not use a metallic pry or any tool which will mar the cylinder while centering it.

2.2.4 The black protection tape is stripped from the upper edge of Cylinder 6 and the top edge of the cylinder is wiped with acetone-dampened cheesecloth to remove any tape residue. The cloth must be changed frequently to prevent contamination of the surfaces.

2.2.5 To assure positive contact for the grounding cables, required when welding, the black tape also is removed in 16 local areas, both inboard and outboard, on the lower edge of Cylinder 6 (Figure 2-1). Each area is approximately 4 inches in length for attaching ground cables. Sixteen equally-spaced ground cables are attached to the cylinder, one near the point of welding, at all times as the assembly rotates.

CAUTION

Do not use any tools that will scratch the aluminum surface when removing the protective tape.

2.2.6 Bear-Tex pads are used to remove the Chem-film in the 16 areas. The ground cable clamps are tightened securely by hand in the 16 areas.

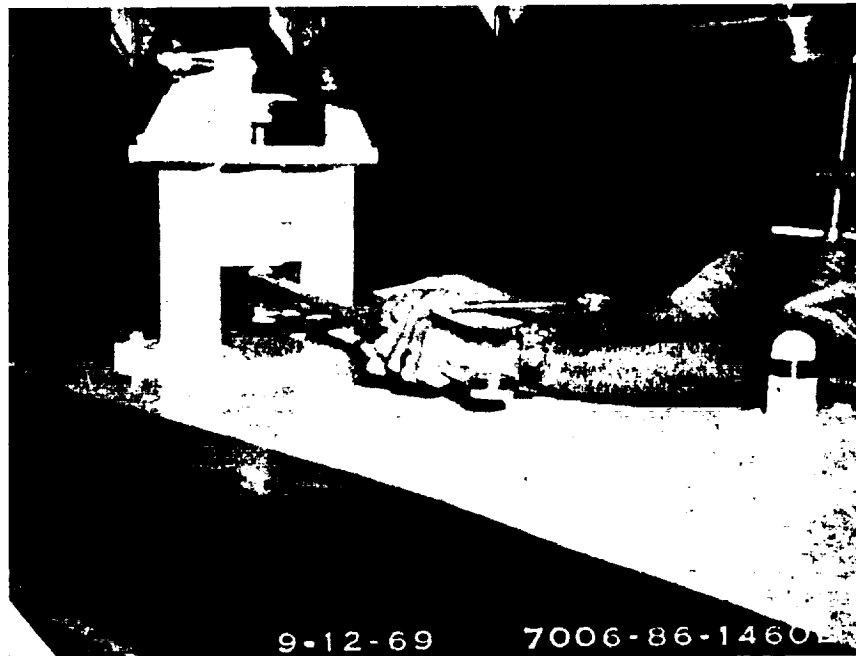


Figure 2-1. Teflon-Protected Screw Jacks



Figure 2-2. Outboard and Inboard Screws



2.3 LEVELING CYLINDER 6 ON ROTATION TOOL

2.3.1 A dial indicator is clamped to the adapter (T-7204291) and the adapter is mounted on the external skate track. The dial indicator is adjusted so that the probe end is centered on the upper butt trim of Cylinder 6. The dial indicator height is set to allow approximately 0.100 inch of travel up or down and the dial face is set at zero.

CAUTION

Before rotating the cylinder, check rotation tool and cylinder clearance. Verify that all electrical cords, hoses, cables, etc., are stowed properly to clear rotating assembly and tooling.

2.3.2 It is verified that the safety key for the rotation control box is not in the lock. The speed control dial is set to 20 inches of travel per minute. The dial is located on the face of the control box. Turntable clearance is verified and personnel are notified to stand clear.

2.3.3 The safety key is inserted in the control box, the turntable rotation started, and the dial indicator monitored. The cylinder must be level within ± 0.030 inch (total indicator deflection 0.060 inch). If the cylinder is level within tolerance, Inspection will verify by placing a stamp in the Fair book.

2.3.4 If the cylinder is not level within tolerance, the Teflon-coated jack screws at the bottom of the cylinder are adjusted (Figure 2-1). The high point of the cylinder, as shown on the dial indicator, is used as a base. The remaining points are raised to bring the cylinder into tolerance and the lock nuts on the jack screws are tightened. Inspection verifies the level of the cylinder and enters it in the FAIR book.

2.3.5 Move control personnel are requested to move the LH₂ bulkhead from storage to Station 1A. Support saddles (T-7204492) are positioned at three equally spaced points around the top edge circumference of Cylinder 6. These saddles fit into notches precut in the LH₂ bulkhead during bulkhead fabrication operations. Final positioning of the saddles is made as the bulkhead is lowered into position (Figures 2-3 and 2-4). Six adjustable saddles (T-7204398) are positioned between the fixed saddles. Portable fluorescent lights are installed and hooked up on the inboard side of the cylinder.

2.3.6 The following operations may continue while the LH₂ bulkhead is in transit but need not be accomplished before the bulkhead is delivered.



Figure 2-3. Lower Edge of Bulkhead in Support Saddles



Figure 2-4. Forward Skirt Attachment Holes



- a. The chip catchers are positioned on the outboard side of the cylinder approximately 6 inches below the top edge. An Aeroquip band is positioned around the cylinder, and the upper flange of each chip trough is clipped under the band. When all sections of the trough are positioned another Aeroquip band is fastened around the lower flange of the troughs. Both bands are tightened by means of the built-in ratchet attachments.
- b. Aluminum tape is used to seal the joints between each chip catcher trough.
- c. A band of 1-inch black tape is used to cover the forward skirt attachment holes located 3-1/4 inches below the top edge of Cylinder 6 (Figure 2-4).
- d. Sheet metal chip catchers are laid on the web of the top frame on the inboard side of Cylinder 6 as shown in Figure 2-5. Aluminum tape is used to seal the edges and joints.

2.4 LOADING BULKHEAD AND SUPPORT TOOLING

2.4.1 Using the overhead handling equipment, the bulkhead is positioned into the support saddles on Cylinder 6.

CAUTION

This operation is performed by the rigging personnel with a move conductor in attendance. Manufacturing has a responsibility to see that the bulkhead is located properly and safely.

2.4.2 While the LH₂ bulkhead is being lowered, six persons are spaced equally around the bulkhead to guide the lower edge into the support saddles as shown in Figure 2-3. The fixed-height saddles must be positioned to match the notches in the bulkhead. As the bulkhead is lowered, the Position I target on the bulkhead is sighted to match the Position I target on Cylinder 6 within 1/2 inch.

2.4.3 The utility boom pedestal is raised into a vertical position on the inner platform and the 4 hex nuts at the base reinstalled. The two boom arms are reinstalled on the pedestal and secured with 4 ball lock pins and the hose quick-disconnects are engaged on the hoses at the top center of the boom. The floodlights are installed on the top of the boom with ball lock pins.



2.4.4 The vacuum manifold is laid on the internal platform close to the inboard side of the cylinder and the manifold hooked up to the utility boom vacuum hose.

2.4.5 A 2-inch length of Mylar tape is placed around the circumference on the inboard side of the cylinder. The bottom edge of the tape is 8 inches below the top edge of Cylinder 6. Three pieces of tape are placed on each quarter-panel 1 inch from each vertical splice weld, right and left, and one piece of tape is placed in the center of the panel. These tape markers will be used to position the lower vacuum support chucks.

CAUTION

Use only tape approved for use on S-II stage.

2.4.6 Dust on the vacuum chucks on the lower support assemblies (T-7204223-701) is removed by wiping with acetone.

2.4.7 The 8 lower support assemblies are installed as shown in Figure 2-6. The top edges of the vacuum chucks are held on the bottom edge of the Mylar tape approximately 8 inches below the upper edge of Cylinder 6. The end chucks of each segment should be spaced between the first and second vertical grids from the vertical weld joints in the cylinders. All segments are held in the same horizontal plane. As each segment is held in position, the vacuum quick-disconnect fitting is plugged into the manifold and vacuum applied. Each chuck is tapped lightly with a mallet to assure seating to the tank wall.

2.4.8 Eight safety poles are installed through the lightening holes in the cylinder frames. The poles rest at the bottom of the turntable with the saddle end at the intersection of the center vacuum chuck bracket and the lower support frame channel (Figure 2-7). The support pole height is obtained by loosening and retightening the slip joint at the approximate center of the pole. The pole must be fitted snugly between the vacuum chucks and the turntable base.

2.4.9 A spreader link is added between the ends of the 8 lower vacuum chucks. The ends of the links are tied to the vacuum chuck frame by means of ball lock pins in each end (Figure 2-5). The 8 expansion links are adjusted outward to a full circle of the vacuum chucks as shown in Figure 2-8. These help support the chucks in the event the vacuum system falters.

2.4.10 Aluminum tape is applied to the inboard surface of the bulkhead to be used to transfer the net trim line. The previously located net trim marks are duplicated on the inboard side of the bulkhead.

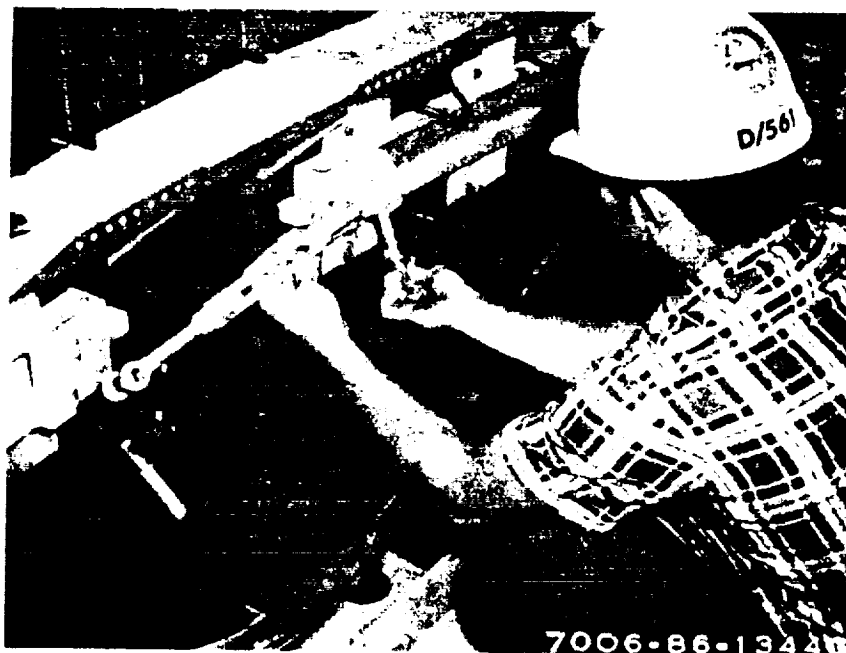


Figure 2-5. Spreader Jack Installation

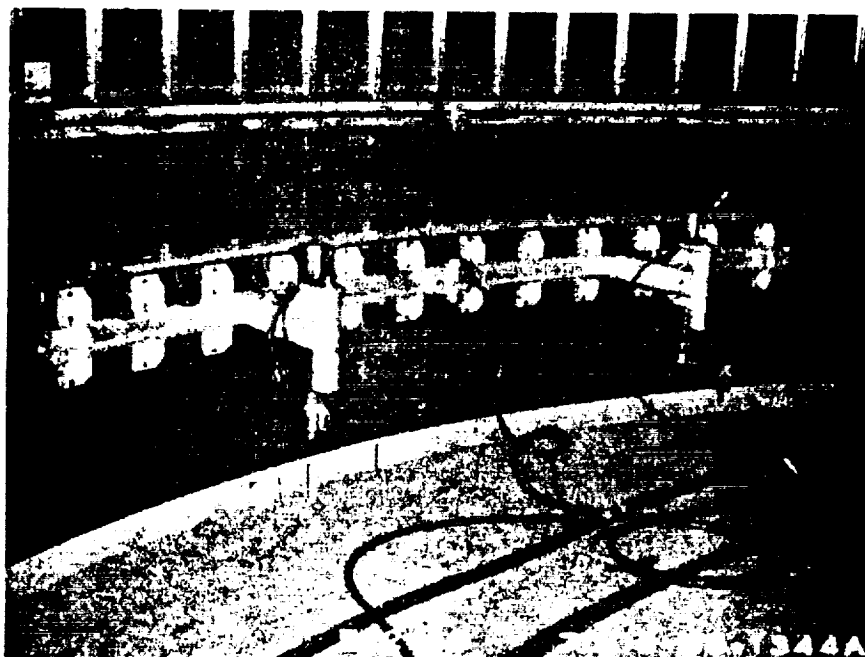


Figure 2-6. Lower Supports

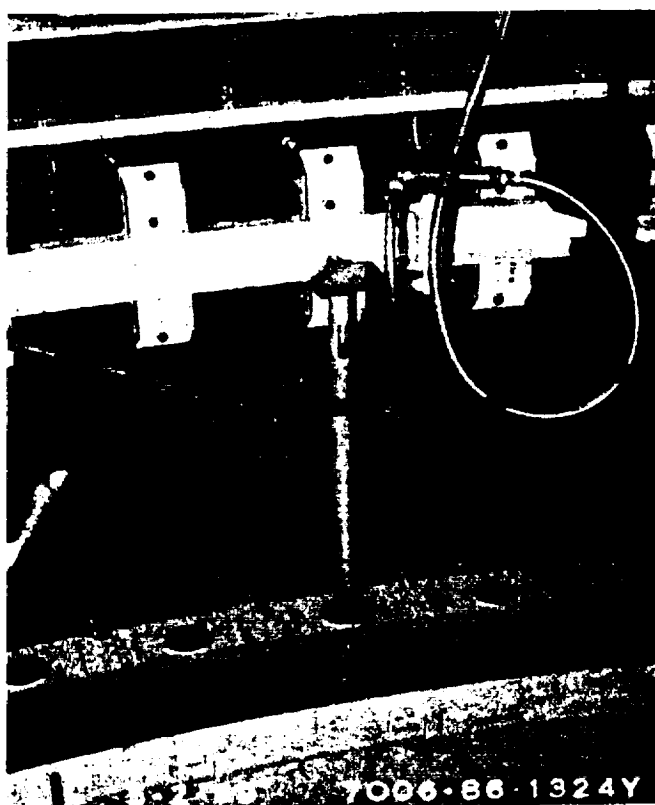


Figure 2-7. Support Post

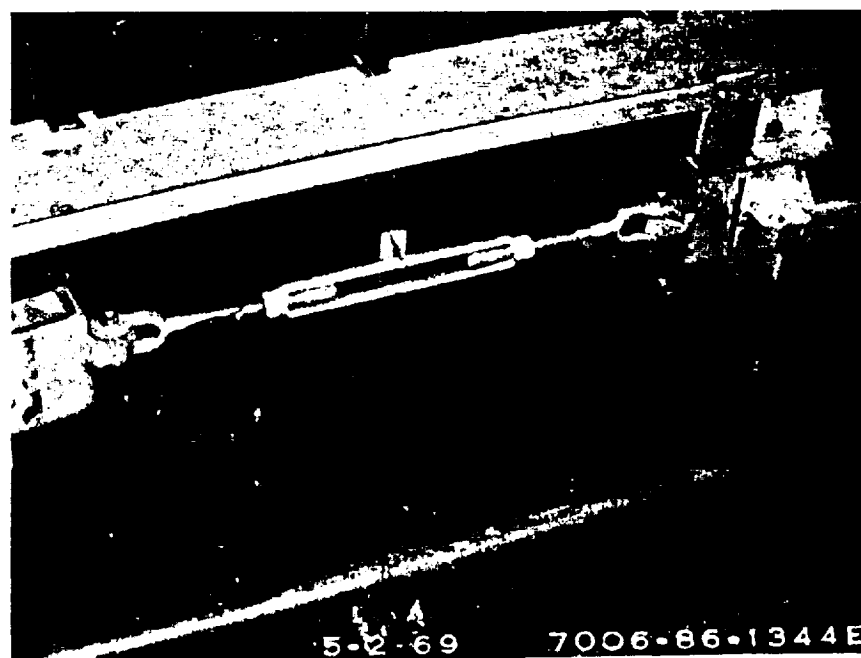


Figure 2-8. Spreader Link Installed (Chip Catcher Above)



2.4.11 The 8 upper vacuum chucks are located on the bulkhead directly above the lower vacuum chucks (Figure 2-9). The lower edge of the vacuum pads is positioned 4-1/2 to 5 inches above the net trim marks on the inboard side of the bulkhead. Vacuum pressure is available by connecting the flex hose from the upper chucks to the quick-disconnect on the lower chucks (Figure 2-10). Each chuck is tapped lightly to eliminate vacuum leaks.

2.4.12 Spreader links are installed between the upper vacuum chucks and expanded by hand to form a continuous band with pressure expanding outward (see Figures 2-5 and 2-8). The upper vacuum chucks are supported by installing 6 control arms (A) into the lower support chuck bearings (B), as shown in Figure 2-11.

2.4.13 The remaining systems are assembled by following the alphabetical sequence described. The horizontal arm (C) is placed on top of the control arm (inboard or outboard) by means of the adjusting screw (D) until the pin (E) can be installed through the arm and the upper vacuum support channel. The bolt on the clamp (F) can be loosened if required to allow the control arm to be raised or lowered. Hydraulic lines from the cylinder (G) to the manifold and rotating beam are connected. The hydraulic cylinder is extended 12 inches. This setting is used with the bulkhead in the support saddles. The clamp (F) at the control arm (A) is tightened and the spanner nut (H) is rotated until 1 inch of thread shows between the spanner nut and support plate (I). The nut is then loosened (Figure 2-11). The clamp (J) is loosened and lowered until it rests on the support plate (I). The clamps (J) are secured. This procedure is repeated until all 16 posts are secured.

2.4.14 The hydraulic pressure manifold is connected to the boom, and the hydraulic reservoir is connected.

2.4.15 Two supports are installed for each set of lower vacuum chucks to support the circumferential sizing tools (see Figures 2-12 and 2-13). The circumferential sizing tools (T-7204223) are installed. The adapter (T-7204223-903) and the hydraulic hoist mounted on the inboard platform are used to install the circumferential sizing tools as shown in Figure 2-9. The turntable is checked for clearance before rotating. Clearance of all hoses during rotation is verified. The turntable is rotated so that the first circumferential sizing tool can be installed as shown in Figure 2-14. The bar is centered on the two supports on the lower vacuum chucks. The turntable is rotated and the remaining 7 circumferential sizing tools hoisted into position.

2.4.16 Spreader jacks (T-7204223-381) are inserted between the ends of the circumferential sizing tools at 8 places (see Figure 2-15). The spreader jacks are attached by means of 1/2-inch-diameter ball lock pins through slotted holes. It may be necessary to pry the last two bars apart to install

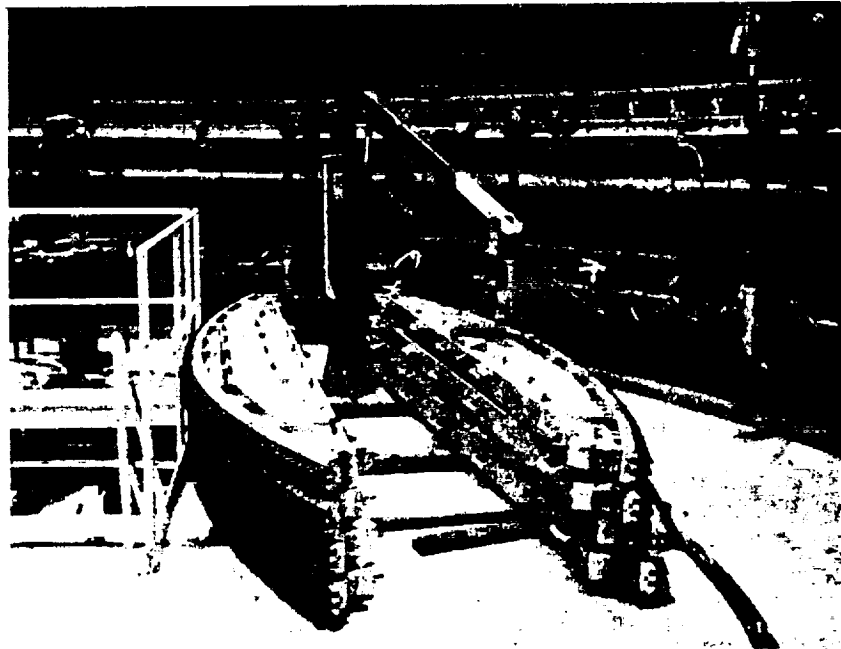


Figure 2-9. Hydraulic Hoist to Lift Sizing Tools

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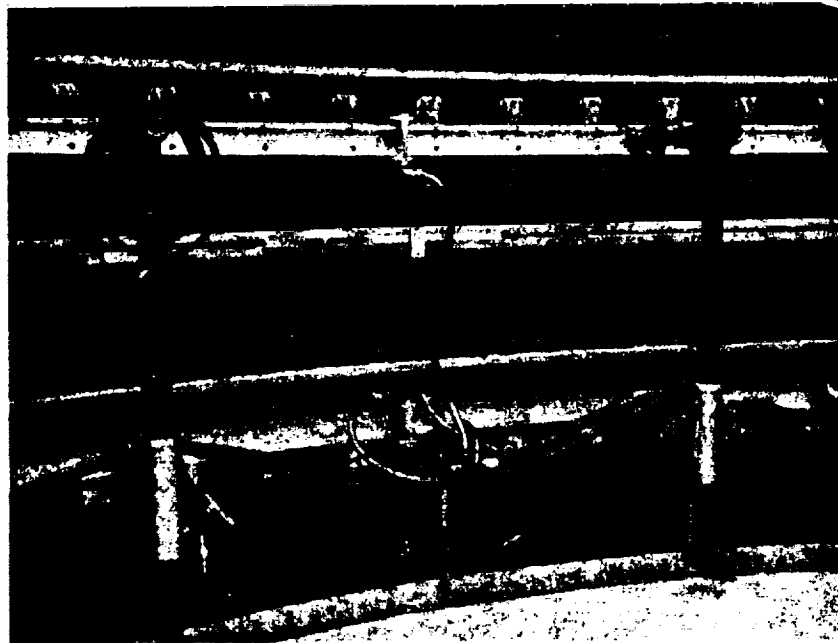


Figure 2-10. Flex Hose Connection

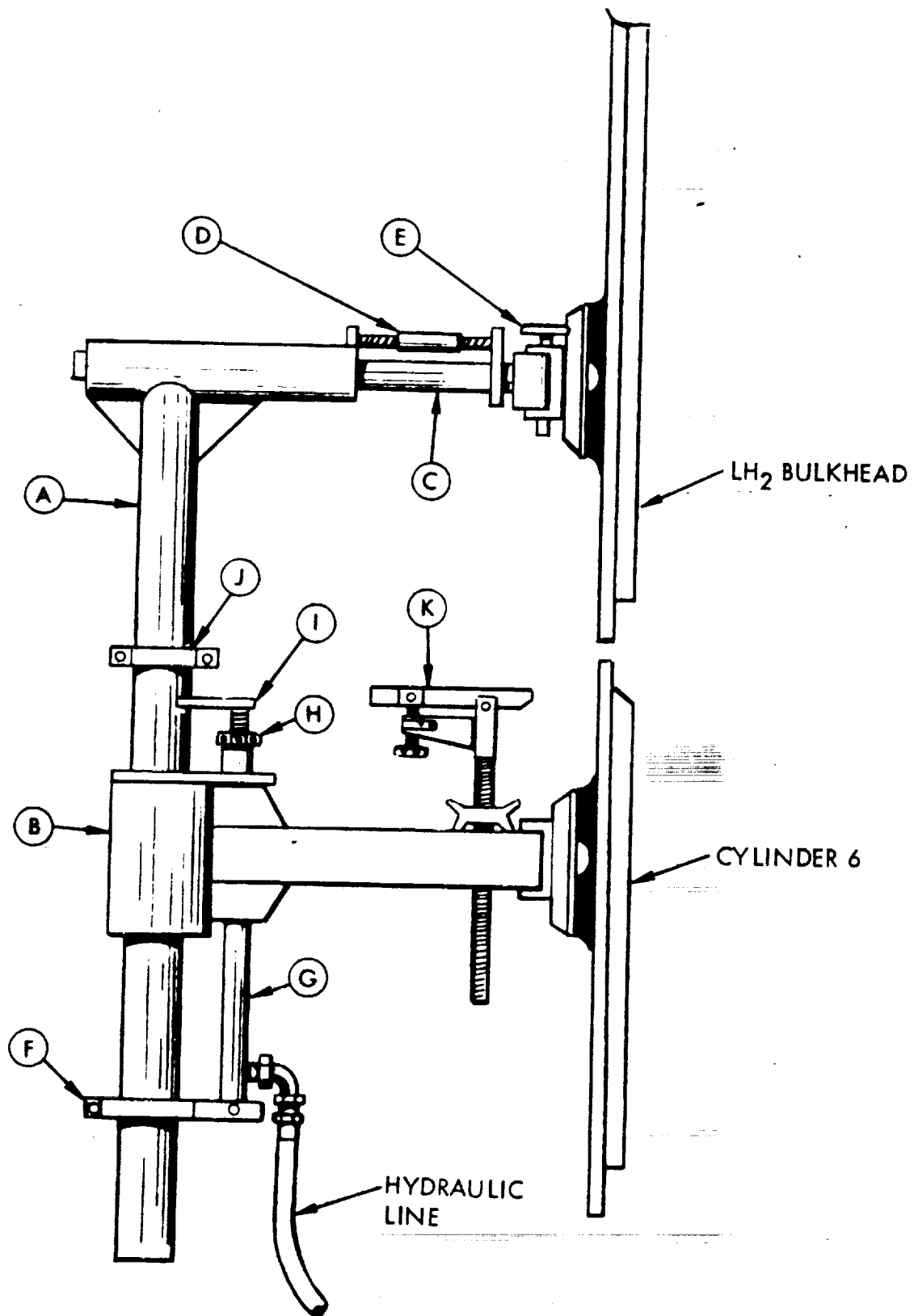


Figure 2-11. Vacuum Chuck Supports

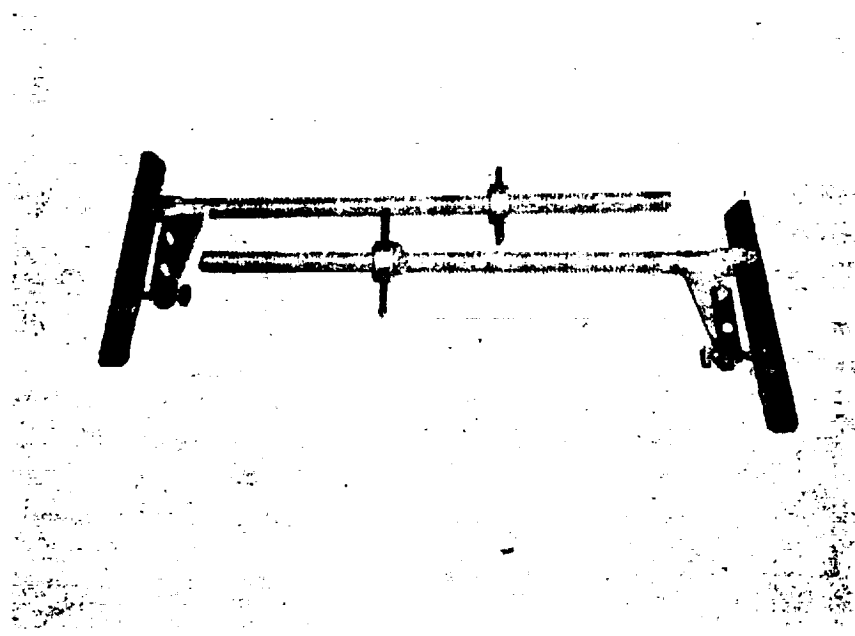


Figure 2-12. Sizing Tool Supports



Figure 2-13. Support Installation

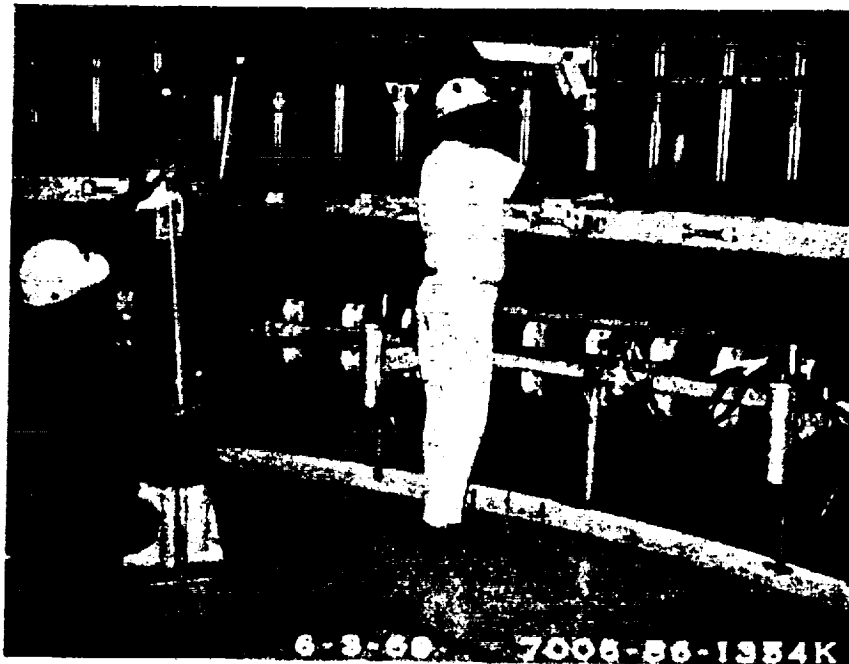


Figure 2-14. Sizing Tool Installation

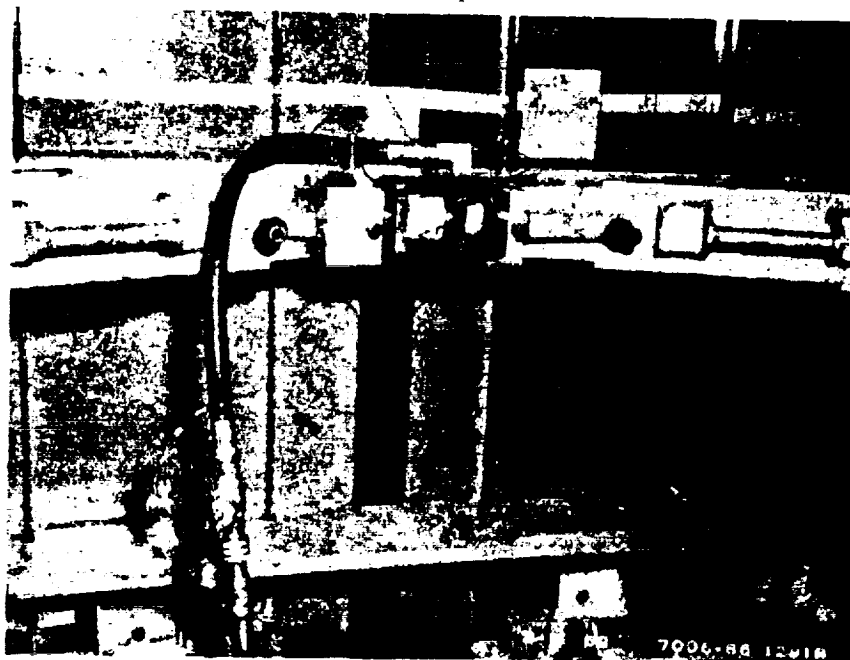


Figure 2-15. Spreader Jack Installed Between Sizing Tools



the last spreader jack. A turnbuckle placed between the ends of the circumferential sizing tools and then expanded, forcing the tools apart enough so that the spreader jack can be installed.

2.4.17 Dust caps are removed from the ends of the hydraulic lines attached to the spreader jacks, the lines connected to the hydraulic manifold (Figure 2-15) and the valves are opened.

2.4.18 The circumferential sizing tools must be centered on the trim lines applied to the aluminum tape decals to establish proper height. Pressure (3000 psig) is applied to the hydraulic system connected to the circumferential sizing tools and the system is checked for leaks. Instructions posted on the hydraulic console are followed.

2.4.19 Centering of the circumferential sizing tools is verified again by sighting through the holes in the fingers of the tools.

2.4.20 The LH₂ bulkhead is leveled using the prick punch marks located 1/2-inch below net trim as a base. Using a trim skate as a surface plate, a height gauge is set to the first set of punch marks at a support saddle. After checking the turntable for clearance inboard and outboard, the turntable is rotated approximately 120 degrees and a second set of punch marks is checked (see Figure 2-16). This procedure is repeated to check the height at 240 degrees for the third set of punch marks. The height gauge is set at the highest punch mark.

2.4.21 The turntable is rotated 1/3 of a revolution (120 degrees) to check the second mark. Shims are placed under the support saddle if necessary to bring the punch marks to the established height. The operation is repeated at 2/3 of a revolution (240 degrees) to level the bulkhead at three locations.

2.4.22 After the three points are leveled, the bulkhead level is checked at three positions and the saddles shimmed as required to level these positions (Figure 2-16). The bulkhead level is then verified at three additional points around the circumference. The turntable is rotated and the height gauge used at each of the three points. The sequence is recorded in the FAIR book.

2.5 TRIMMING LH₂ BULKHEAD

2.5.1 The trim saw is installed on the weld skate pedestal and bolted to the pedestal with four bolts.



Figure 2-16. Bulkhead Leveling Using Height Gauge

CAUTION

Check the condition of the saw blade. Look for chipped or lost carbide tips on the teeth. Replace the blade if damaged.

2.5.2 The handwheel on the top of the saw is used to adjust the height to saw 1-1/8 inch below net trim on the bulkhead. The vertical slide is locked by means of the lock screw on the left-hand side of the vertical gib; this is a safeguard to prevent the saw from an accidental change of height.

2.5.3 Using a contour template with a 198-inch radius, the contour of the bulkhead is checked across each of the eight circumferential sizing tool spreader jacks at the net trim line. If the mold line contour is out more than 0.060 inch, the sizing tool fingers are adjusted to bring the mold line into contour. The fingers are adjusted by means of the bolts located on the bars (Figure 2-17).

2.5.4 Clearance on the turntable both inboard and outboard side is verified. Turntable speed is set at 12 inches per minute.



2. 5. 5 The depth adjustment roller on the trim saw is set to allow the saw blade to cut through the material as shown in Figure 2-18, and the safety lock is secured to prevent any change in blade depth. Once the motor is started, it is adjusted by means of the screw on the cross slide to move the saw blade in until it makes a mark approximately 0.010-inch deep in the bulkhead surface. The saw is withdrawn, the turntable is rotated 120 degrees, and a similar mark is made. The operation is repeated at 240 degrees. The distance from the net trim line to the saw marks is checked at the three places to verify that the saw cut will be parallel to the trim mark with a tolerance of ± 0.030 inch.

2. 5. 6 If the marks are not parallel to the trim, the bulkhead assembly is leveled to meet trim tolerance per sequence Steps 2. 4. 20 to 2. 4. 22. If the marks are parallel to the net trim line within ± 0.030 inch, the rough trim can be made. The next operation requires rotation of the turntable so that the center of the saw blade is approximately 6 inches past the center of a saddle. The depth stop is adjusted until the saw cuts through the material and the depth stop roller bears on the material (Figure 2-3).

2. 5. 7 The turntable rotation is started in the direction so that the cut is away from the saddle. Cutting is continued until the center of the saw blade is approximately 6 inches from the center of the next saddle at which time the screw on the depth feed is turned to retract and clears the material. This operation is repeated at each saddle supporting the bulkhead. This leaves 12 inches of untrimmed bulkhead support at each saddle.

CAUTION

When trimming the bulkhead it may be necessary to wedge a 5/32-inch shim into the cut behind the saw to prevent the trimmed material from pinching the saw blade (see Figure 2-18).

2. 5. 8 With a power hacksaw, a vertical cut is made from the lower edge of the bulkhead to the rough cut on each side of the support saddles. The material is held when making the second vertical cut on each segment so that the trim material does not vibrate with the saw or fall when the cut is completed. The scrap material is marked to identify the gore from which it was removed and stored in the work area.

2. 5. 9 To make the net trim on the bulkhead the lower screw on the vertical gib of the saw is loosened and the blade adjusted to the net trim line.

CAUTION

The top edge of the saw blade must be on the net trim line. The lock screw on the vertical gib is tightened to assure stability of the saw blade (Figure 2-18).

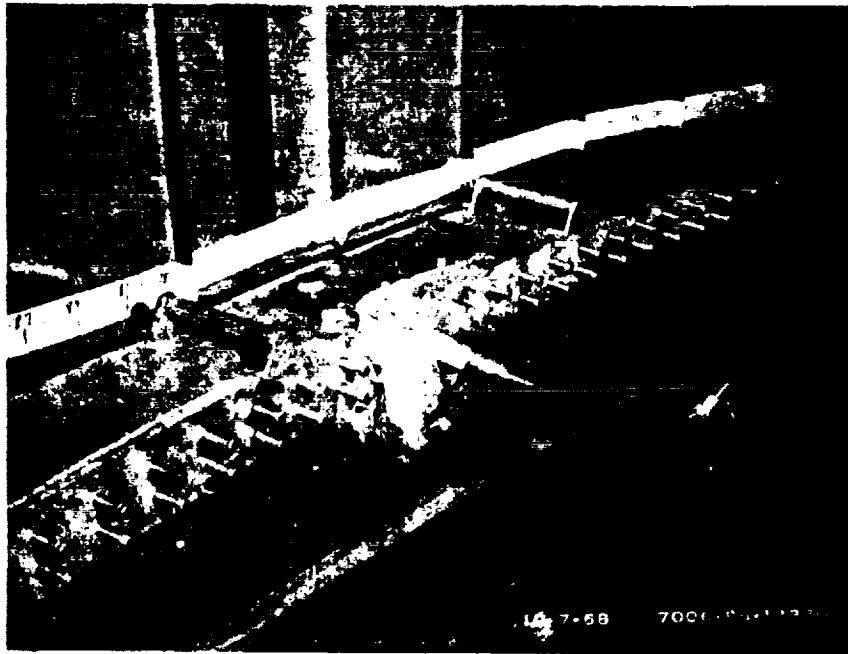


Figure 2-17. Sizing Tool Finger Adjustment

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Figure 2-18. Saw With Depth Adjustment

When making the cut the stop is set on the saw blade to a limit of 3/4-inch penetration to prevent damage to the backup bars.

2.5.10 The saw is moved into the material until the stop roller rides on the bulkhead. Turntable rotation is started for the final trim and is not stopped until the rotation is complete to prevent a step in the trimmed edge. As the saw progresses over a support saddle, a 0.150-inch aluminum shim is inserted into the cut to prevent the bulkhead from accidentally dropping and causing damage to the trim edge (see Figure 2-4). Additional 0.150-inch shims are used as required to prevent binding of saw blade.

2.5.11 Scrap is removed by cutting excess material vertically with a power hacksaw. All scrap, including that previously stored in the work area, is cut into 3-foot lengths and taped into bundles which are weighed and logged.

2.5.12 Circumferential sizing tool pressure is released and the hydraulic jacks actuated to raise the bulkhead approximately 6-1/2 inches (Figure 2-19). Each line connects to a 1/3 section of the manifold and raises and lowers 1/3 of the bulkhead.



Figure 2-19. Installation of Safety Blocks Under Bulkhead



- 2.5.13 Four safety blocks are installed between the bulkhead and Cylinder 6 (Figure 2-19). C clamps are used to hold the blocks in place and padded with aluminum foil where they touch the part.
- 2.5.14 The valves are turned off at each hydraulic jack and the air line disconnected at the hydraulic pump. Ball lock pins are removed at each end of the circumferential sizing tool spreader jacks and the 8 spreader jacks are removed (Figure 2-15). The valves are turned off on each hydraulic line and the quick-disconnects released at the manifold. The jacks are stored neatly on the floor of the internal platform.
- 2.5.15 The first circumferential sizing tool is removed by use of the hydraulic hoist. After the rotation table is checked for clearance, it is rotated in position for removing the second tool. These operations are repeated for the removal of the remaining circumferential sizing tools. The tools are neatly stored on the internal platform, four to a stack (Figure 2-9).
- 2.5.16 All chips are removed from the assembly, tooling, and the floor by use of a vacuum cleaner. The trim saw is removed from the pedestal and stored properly.
- 2.5.17 A pi-tape reading is taken on the circumference of the LH₂ bulkhead at the completed trim line and the dimensions recorded in the FAIR book.

CAUTION

Use only approved masking tape to hold the pi-tape to the assembly. Certified personnel only are to record pi-tape readings.

- 2.5.18 A stainless steel tape, marked in 3-inch increments, is attached to Cylinder 6 approximately 4 inches below the upper edge to be used for position markers (Figure 2-4). This is a shop aid.

CAUTION

Use only approved tape to hold the stainless steel tape to the assembly.

- 2.5.19 A Mylar tape strip is installed 4 inches above the trim line on the inboard side of the LH₂ bulkhead. One-inch masking tape is placed over the Mylar tape and cross-marks are applied to the masking tape in 3-inch increments for reference locations.



2.5.20 The Position I mark on Cylinder 6 and the Position I mark on the LH₂ bulkhead are to be in line within 1/8 inch. If the position markers do not line up, the bulkhead is rotated by pushing on the control arms of the upper set of vacuum chucks in the direction desired. Four to six men equally spaced around the inboard side can move the bulkhead assembly as required.

CAUTION

The C clamps are loosened on the safety blocks prior to rotating the bulkhead and retightened after rotation (Figure 2-19).

2.5.21 A 12-inch combination square is used to transfer the 3-inch increment marks from the number tape on the outboard side of Cylinder 6 to the inboard side of the LH₂ bulkhead. The head of the square is placed on the butt edge of the cylinder with the scale projecting 5 inches below the butt edge to the tape on the outboard of Cylinder 6. The upper end of the scale is to be on the inboard side of the LH₂ bulkhead. Align one edge of the scale on an increment line on the Cylinder 6 tape and with a marking pen mark the tape on the inboard side of the LH₂ bulkhead. The increments are numbered to correspond to Cylinder 6 tape (Figure 2-15).

2.5.22 Inspection takes thickness readings at 3-inch increments on the top of Cylinder 6 and the bottom of the LH₂ bulkhead. These thicknesses are entered on an Inspection Test Instructions (ITI) sheet and logged in the FAIR book.

2.6 PREWELD CLEANING

2.6.1 Follow procedures described in Weld Preparation and Cleaning Operations, Section 1.12.

2.7 STATION PREPARATION AND TOOLING INSTALLATION

2.7.1 During the weld preclean operations, the circumferential sizing tools are checked for nicks and burrs on the fingers which contact the weld lands. Any defects are draw-filed with a mill file and wiped with acetone using clean cheesecloth. The tools are wrapped with kraft paper until ready for use. The station temperature and humidity is verified. The temperature must be a minimum of 76 F and the humidity a maximum of 50 percent. If either exceeds the allowables, Maintenance is called to correct the condition.

2.7.2 The turntable is rotated so that the first circumferential sizing tool can be set on the supports of the lower vacuum chucks.



CAUTION

Check turntable clearance before rotating table.

The first circumferential sizing tool is hoisted using the hydrolift and the arm moved to position the bar on the T-supports and centered on the lower vacuum chucks. The turntable is rotated and the remaining seven circumferential sizing tools are progressively hoisted into position. The spreader jacks (T-7204223-381) are installed between the circumferential sizing tools at eight places. The spreaders are attached by means of 1/2-inch-diameter ball lock pins through the slotted holes. It may be necessary to pry the last two sizing tools apart to install the last spreader jacks. A turnbuckle is placed between the ends of the tools and expanded to force the tools apart enough for the spreader jack to be installed.

CAUTION

Do not allow bars to contact cleaned edges of the cylinders.

2.7.3 The dust caps are removed from the end of the hydraulic lines attached to the spreader jacks, the lines connected to the hydraulic manifold and the valves are opened. If the spreader jacks are not wrapped in plastic, it is wrapped around them to prevent hydraulic oil from contaminating the cleaned weld surface in case of hydraulic leaks.

2.7.4 The height of the circumferential sizing tools is checked; the top edge of Cylinder 6 must be within 1/16 inch below the centerline of the backup groove. The height of the circumferential sizing tool is adjusted if required by means of the adjusting wing nut (L). A level is set on top of the circumferential sizing tools and the tools leveled by means of the thumb nut on the support (K) (see Figure 2-20).

CAUTION

Do not contact the cleaned surfaces of the cylinders while leveling the circumferential sizing tools.

2.7.5 The hydraulic jacks (G) in Figure 2-11 are used to lower the LH₂ bulkhead over the circumferential sizing tools until a 1/16- to 1/2-inch gap exists between the cylinder and the bulkhead (Clamp I should rest on J at the 12 locations) around the circumference.

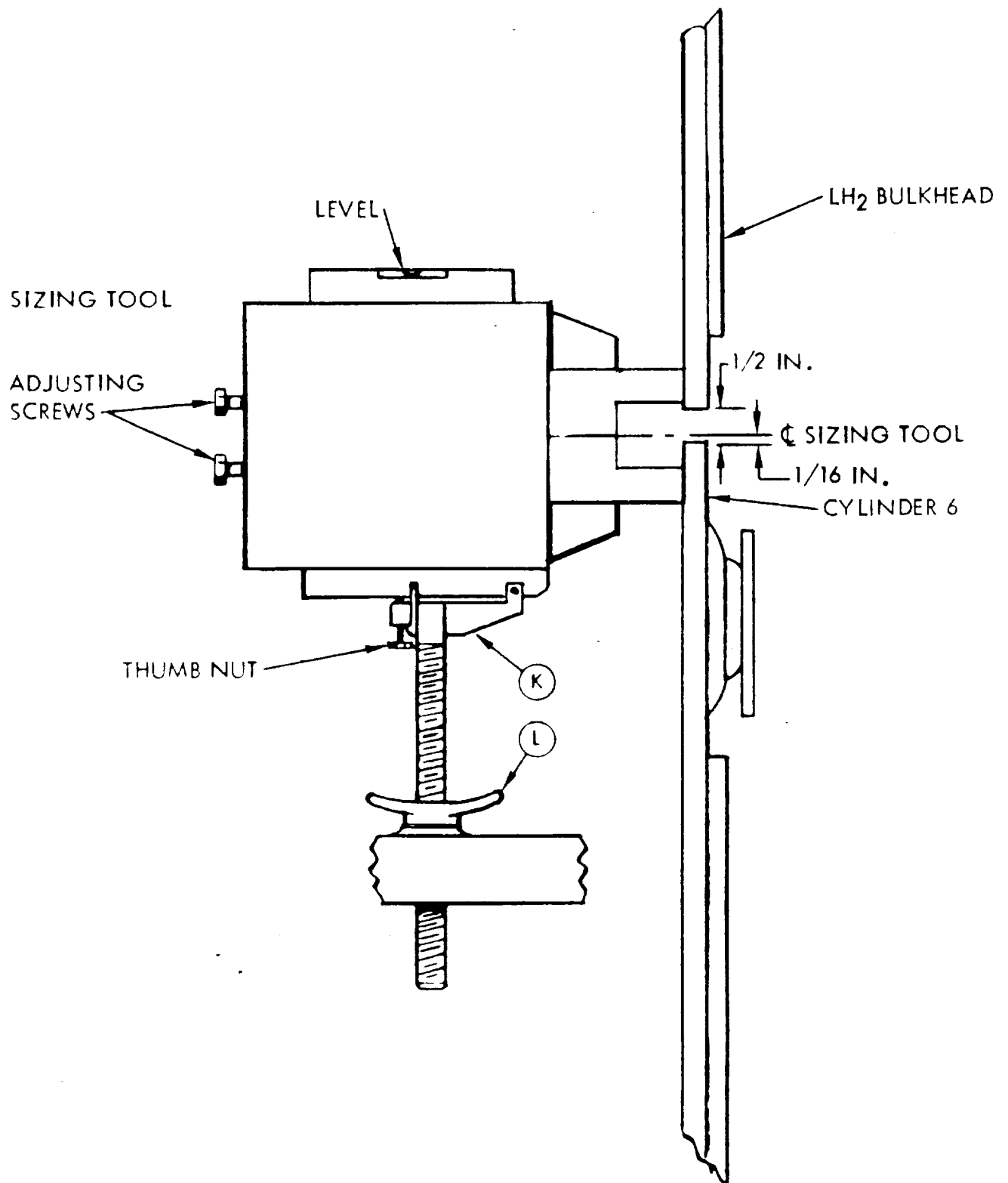


Figure 2-20. Height Adjustment

CAUTION

Follow instructions on hydraulic pump for lowering the LH₂ bulkhead. Only qualified personnel are to operate the pump. Use extreme care in lowering and continually check around circumference so that the butt face of the LH₂ bulkhead does not contact the circumferential sizing tool fingers.

2.7.6 The circumferential sizing tools are pressurized to 3000 psi; this should occur near a shift change. The joint is covered with aluminum foil on the inboard and outboard side using only approved tapes.

CAUTION

Do not contaminate joint area.

2.8 WELD PREPARATION AND CLEANING

2.8.1 These operations are to be performed per procedures described in Weld Preparation and Cleaning Operations, Section 1.12.

2.8.2 As soon as the blacklight inspection is completed, the tooling department will set up a line-of-sight tool on a base attached to a building column. The Position I mark on Cylinder 6 will be rotated so that it can be read through the instrument. The Position I mark on the LH₂ bulkhead is checked and must be within 0.030-inch of the position mark on Cylinder 6. If it does not line up, the circumferential sizing tool pressure is lowered and the bulkhead rotated by pushing on the upper control arms of the vacuum supports on the inboard side.

2.8.3 The white lights are turned on and preparations are made for lowering the LH₂ bulkhead. The circumferential sizing tool pressure is lowered to 500 psig if it had not been lowered for alignment check. Precleaned 0.040-inch stainless steel shims are installed at 12 equally spaced points around the circumference of Cylinder 6. The spacers are secured by Mylar tape to the outside surface of Cylinder 6. One leg of the shim must project from 1/2- to 3/4-inch onto the material thickness of the cylinder butt edge. These shims are used to prevent the LH₂ bulkhead from bearing on Cylinder 6 during the lowering and rotational alignment operations.



CAUTION

Preclean the shims with acetone before installation. Do not contaminate the shims during installation. Use only approved tape on the cylinder surface.

2.8.4 The LH₂ bulkhead is lowered by the use of a spanner wrench on the nuts (H) shown in Figure 2-11. The bulkhead is progressively lowered by turning the nuts counterclockwise on the 16 support jacks (G). The rotational alignment operation is monitored from the outboard side of the assembly as the bulkhead is lowered. The bulkhead is lowered until there is approximately 1/8-inch gap around the circumference.

2.8.5 Rotational alignment is checked by means of the optical line-of-sight instrument. Tolerance must be kept within 0.030 inch. The target is to hold rotational alignment within 0.010 inch. The circumferential sizing tool pressure may have to be lowered to zero and the LH₂ bulkhead rotated by pushing the bulkhead in the required direction on the inboard side. In extreme cases a cable hookup and turnbuckle can be used for rotation (Figure 2-21).

2.8.6 The circumferential sizing tools are pressurized to 500 psi if the pressure has been lowered for rotation. The bulkhead is lowered at Position I (approximately) to 0.040-inch gap, and rotational alignment is checked again. The circumferential sizing tools are pressurized to 6000 psig.

CAUTION

Only qualified persons are to operate the hydraulic pump.

2.8.7 Rotational alignment is verified by inspection and the item cleared in the FAIR book. The approval to weld is verified and entered in the FAIR book.

2.8.8 During the final cleaning operation, the welders and the weld engineers verify the equipment. The gas is checked for moisture content, the wire is checked, and the heat treat number, size, etc., is logged in the FAIR book. A bead-on verification plate is run and checked by Quality Control, which also checks the machine settings. The weld heads are then moved to the skate track at each weld position. The welder connects the ground and sensing leads to the assembly, and these are then checked by the weld engineer.

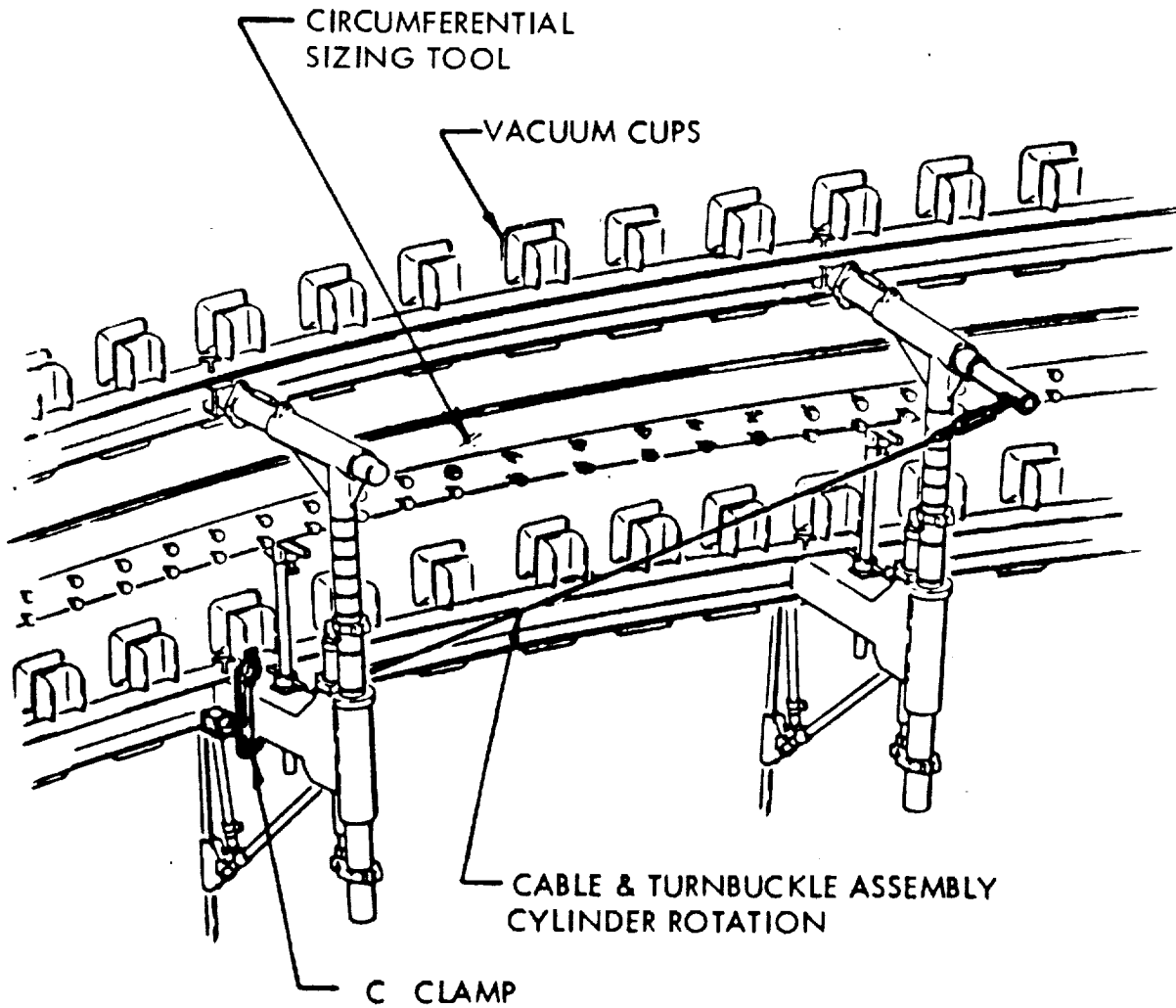


Figure 2-21. Use of Cable for Rotation



2.9 WELDING OPERATIONS

2.9.1 The tack-weld team consists of a welder, an offset manipulator, a vacuum hose operator, and a weld engineer on the outboard side, and an offset manipulator on the inboard side. A team consisting of a man on the outboard side and a man on the inboard side, for each weld station, presets the offset ahead of the tacking crew.

CAUTION

Never look directly at the weld arc. The welders and other team members who must observe the arc must use approved eye shields or welding glasses.

2.9.2 Communication between the outboard and inboard side is by means of intercom headsets. Using a 0.050-inch thick stainless steel gauge, the manipulator checks the offset and informs the man on the inboard side which assembly must be moved to arrive at a target of 0.010-inch offset (Figure 2-17). The inside man adjusts the offset by means of the adjustment bolts on the inboard side of the circumferential sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers.

2.9.3 The first tack is located at approximately Position I, where a gap of 0.040 inch exists. The offset is set by the manipulating team, and the vacuum hose man vacuums the area to remove foreign material from the faces of the cylinder or bulkhead. The weld head is then moved into position for the first tack and locked to the gear rack on the track. The torch is positioned for the tack and the circumferential sizing tool pressure of 6000 psi is verified. The weld head is programmed to the intermittent tack parameters per Weld Schedule 971-D-00265. A 3-inch long tack (plus taper out) is run. A 6-inch space is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for four to five tacks. After these, the rotational alignment tools are removed. The 0.040-inch stainless steel shims are also removed.

2.9.4 The gap around the assemblies is checked, and if the gap 180 degrees from the first tacks exceeds 0.040 inch, the circumferential sizing tool pressure is lowered to 500 psi. The LH₂ bulkhead is then lowered to a 0.040-inch gap. If required, the assemblies can be pulled together by means of a large clamp (T-7204223-126) as shown in Figure 2-22. When the gap is determined to be 0.040 inch at Position III or 180 degrees from the first tacks, the circumferential sizing tool is pressurized to 6000 psi and the tacking operation can begin at the second weld position using the same alignment procedures.

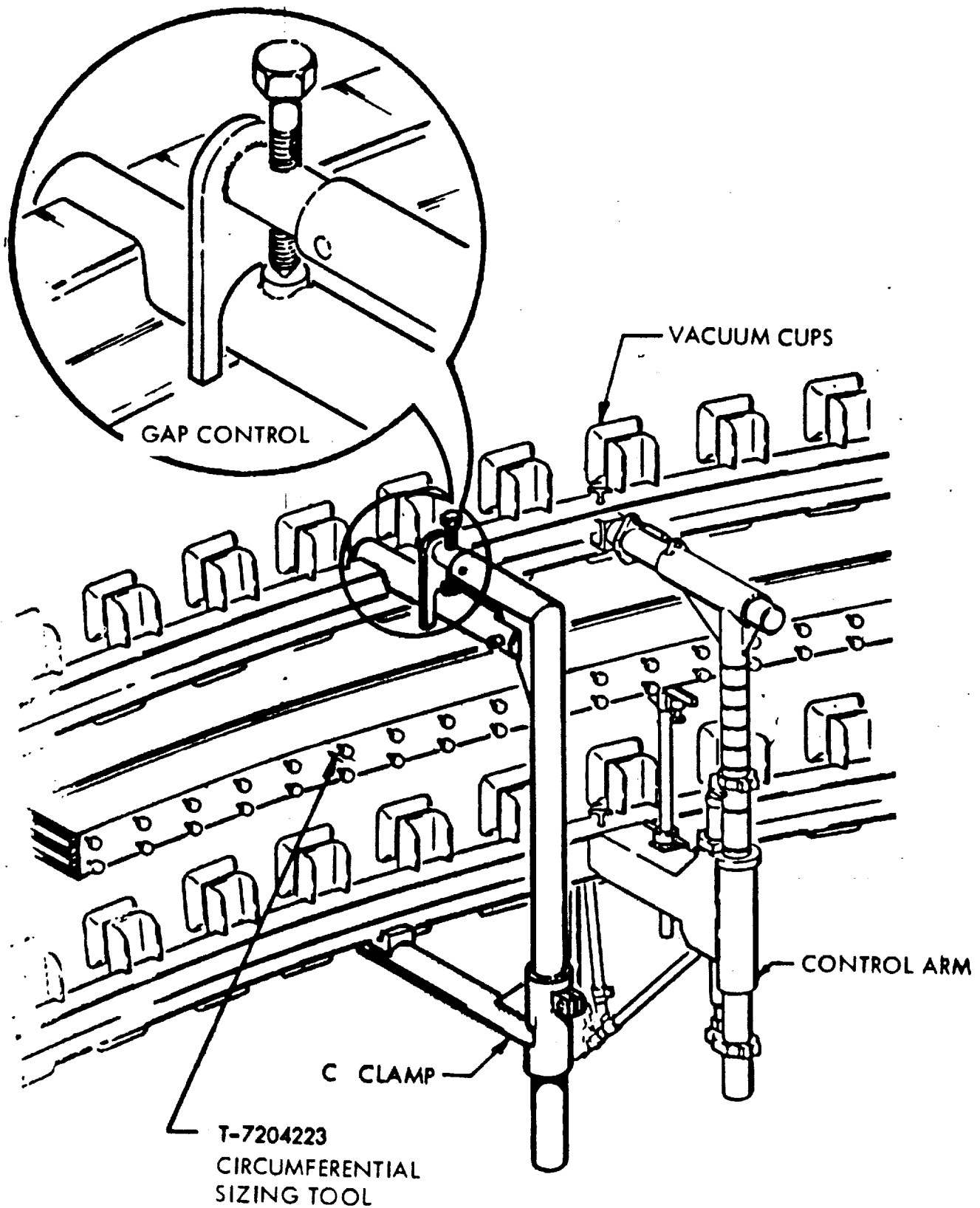


Figure 2-22. C Clamp for Drawing Cylinders Together



2.9.5 The assemblies are progressively tack-welded at the two weld stations with 3-inch long tacks at 9-inch centers. When each weld machine has tacked the assemblies the full length of the skate track, approximately 8 feet, the turntable is rotated to allow a second series of tacks. The turntable is usually rotated to a new tack position 7 times. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.015-inch offset after welding is evaluated by supervision and will be reworked if required.

2.9.6 When tacking operations are complete, the circumferential sizing tool centering is checked and pressure is reduced to recenter the tools on the joint if required. The tool is then repressurized to 6000 psig. All adjusting screws are backed off to zero and readjusted finger-tight to assure contact of the circumferential sizing tool with the assemblies.

CAUTION

Do not over-tighten screws.

2.9.7 The weld machine parameters are programmed for continuous tack pass per 971-D-00265. The turntable speed is set on the turntable control box and the direction of travel checked. Travel is in a clockwise direction or from left to right. An air motor is set up at each weld station with a 1/4-inch ball rotary file; this is used to grind out the minute craters left when the weld machine sequences out after running the continuous tack pass.

2.9.8 The weld heads are positioned at the right-hand end of the skate tracks. Allowance is made for enough skate travel to sequence out the weld heads in the event the turntable malfunctions. Weld heads are locked into the track and the travel potentiometer set for the correct skate speed. In the event that the turntable stops, the welder must immediately switch on the skate travel switch and then sequence out.

2.9.9 A final check is made on turntable speed and direction of travel, weld machine settings, skate lock-in, and circumferential sizing tool pressure. A countdown is called out on the intercom and at the words, "sequence-start", both welders energize their weld machines. As soon as both arcs stabilize, the turntable is started. In the event that one machine fails to start, two courses are open to the supervisor or weld engineers: the operating machine can continue while the second machine is checked out for the cause of the misfire, and then fire it into a running start, or the operating weld head can be sequenced out until the second machine is checked, and then both machines are restarted.

2.9.10 The continuous tack pass is run with each machine overlapping the start of the other machine for a minimum distance of 16 inches, or until a good tie-in is made.



2.9.11 As each machine sequences out for any reason, the tailout crater is ground out to a depth of approximately 0.060-inch with the ball rotary file. The tailout crater is ground as soon as the welding arc is terminated to prevent any small cracks from occurring.

CAUTION

Do not shut off turntable until both machines have sequenced out.

2.9.12 As the continuous tack pass cools down, the circumferential sizing tools are again checked for centering and adjusted. If the sizing tools are moved, they are repressurized to 6000 psi.

2.9.13 Using a fine stainless steel rotary brush in an air motor, the entire cover tack pass is wire-brushed, moving the brush in long strokes in one direction only. The dust and soot are vacuum-cleaned from the area.

CAUTION

Do not touch surface of weld land with any material except the wire brush.

2.9.14 The weld machines are reprogrammed to the penetration weld parameters 971-D-00265 and are verified by Inspection. The current override control is moved to the inside of the cylinder and the control switch on the weld pack is turned on. The phone communications are checked between inboard and outboard at each weld station, and the circumferential sizing tool pressure and centering are checked. The turntable speed is reset for the penetration pass. An air motor with a 1/4-inch ball rotary file is positioned at each weld station, and the lock securing the weld head to the skate track is verified. The proper speed at the pendant station potentiometer also is verified.

2.9.15 Two welders are positioned on the inboard side and in contact with the welders on the outboard side by means of the phones. Countdown is started and at sequence start both weld machines are energized. When the arc stabilizes, the turntable rotation is started.

2.9.16 The welders on the inboard side control the amount of drop-through on the penetration pass and also are responsible for tracking the seam. The drop-through is watched by means of sight holes in the circumferential sizing tools.



CAUTION

Check cables on the inboard side as the boom rotates so they do not hang up.

2.9.17 The penetration pass is run. Each machine will overlap the penetration of the other machine a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground to a depth of approximately 0.060 inch. A visual check assures that all tailout crater defects are removed.

2.9.18 The drop-through side is checked for incomplete penetration. If any incomplete penetration exists, the turntable is rotated to bring the area to the closest weld head. The incomplete penetration can be picked up by either weld machine, using the skate travel of the head instead of the turntable rotation.

2.9.19 After the pickup operations permitted by the 971-D-00265 weld schedule are complete, or after the penetration pass, the circumferential sizing tool pressure is released. The eight spreader jacks are removed and stored on the inboard side of the cylinders. The turntable is checked for clearance, both inboard and outboard, and rotated to position a circumferential sizing tool at the hydrolift. Using the hydrolift and the adapter (T-7204223-903), the first circumferential sizing tool is removed. The turntable is rotated to remove the remaining seven bars. The bars are stored on the internal platform. The eight upper vacuum chucks are then removed as well as the 16 support arms (Item A in Figure 2-11).

CAUTION

Do not remove the lower chucks.

2.9.20 Visual inspection is made of the drop-through side of the weldment for undercut, incomplete penetration, folds, etc., per Specification MA0107-016. Inspection verifies the drop-through and prepares a reference squawk if required.

2.9.21 Using three or four weld shavers, the weld bead is milled on the inboard side to a height of 0.010 to 0.015 inch.

CAUTION

Do not cut into the parent metal with the shavers.



2.9.22 A Bear-TeX wheel is used in an air motor to abrade the inboard side of the weld. Long even pressure strokes are used and the wheel is not allowed to pause in any one area.

CAUTION

Do not run the Bear-TeX wheels crosswise or at angles to the weld.

2.9.23 A fine stainless steel rotary brush is used to remove the soot from the outside of the weld. The penetration side (outboard) is checked for any folds, etc., that must be blended out with a ball rotary file prior to X ray. The inboard and outboard sides are then wiped using clean cheesecloth and acetone.

2.9.24 The penetration weld pass is X-rayed by qualified inspection personnel, the film read out, and report prepared. Triangulation shots are made and location of defects by view, depth, and inch marks is indicated on the report. The Manufacturing supervisor and weld engineer determine which of the defects should be reworked prior to putting the cover passes on the weld. A Manufacturing Request for Rework (Form 021S) is filled out requesting planning tickets for in-process rework.

2.9.25 Defective areas are reworked as defined in Section 10, Weld Repair Techniques. The circumferential sizing tools are reinstalled as described in Steps 2.7.2 to 2.7.4 and pressurized to 6000 psig. The circumferential sizing tools are checked for hydraulic leaks.

2.9.26 White garments must be worn during the following operation. The outboard side of the weld is brushed with a clean fine stainless steel rotary brush in an air motor. Long strokes in one direction only are used.

2.9.27 The parameters on the weld packs are reprogrammed per 971-D-00265 for the cover pass weld.

CAUTION

The override control is to remain in the off position.

The weld head is again locked to the skate track and speed potentiometer is set for proper speed at the pendant station. The circumferential sizing tool pressure, the turntable speed and direction of travel, and skate lock are verified in preparation for weld. An air motor with a 1/4-inch ball rotary file is again positioned at each weld station and the weld also is wire-brushed and vacuum-cleaned.

2.9.28 The countdown is started and at sequence start both machines are energized. When the arcs stabilize, turntable rotation is started. The first cover pass is run and the operator makes sure that the bottom edge of the penetration pass is covered by the cover pass. The cover passes must overlap at least 6 inches before sequencing out.

2.9.29 Tailout craters are then ground out with ball rotary file, the cover pass is wire-brushed and the entire circumference inspected for lack-of-fill areas. The determination then is made on whether to run a complete second cover pass or intermittent pickups.

2.9.30 The second cover pass is run if required, using Steps 2.9.26 to 2.9.29. If intermittent pickups are required, the turntable or the skate track is used, depending on the length of the area. After the second cover pass or intermittent pickups, the weld is inspected again for defects. The circumferential sizing tools are removed per Step 2.9.19. Weld shavers are then used to mill the cover passes to 0.010 to 0.015-inch height.

CAUTION

Do not touch the parent material.

The milled weld bead is abraded with Bear-Tex, moving the wheel in long strokes. Do not use Bear-Tex wheel across the weld bead.

2.10 POST-WELD OPERATIONS

2.10.1 Quality Control personnel X-ray the entire weld, the film is read out, and triangulation shots are made of any questionable areas. If rework is required it may be accomplished by the in-process method or by MR action.

2.10.2 After X ray is complete, the joint is inspected both inboard and outboard with fluorescent penetrant. Manufacturing personnel assist fluorescent inspection by blending out defects if they do not lie below the parent material thickness. After the X ray and fluorescent inspections are completed, the sequences are cleared in the FAIR book.

2.10.3 The weld land on the inboard and outboard side is Chem-filmed. This is an operation requiring personnel certified in manual chemical processing applications. When the Chem-film has dried for a minimum of 12 hours, the weld land area is covered with an approved tape or blue vinyl coating.

2.10.4 The FAIR book is checked for approvals on all items and recapped.

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3.0 CYLINDER 4 TO CYLINDER 5 CIRCUMFERENTIAL WELD

3.1 GENERAL DESCRIPTION

3.1.1 The techniques and procedures utilized in the circumferential welding of Cylinder 4 to Cylinder 5 are described in this section. The operation is performed in Station 1A with Cylinders 4 and 5 mounted on tool T-7204224 (Figure 3-1). The cylinders are rotated and the two weld heads, positioned at 180 degrees, are held stationary. Included in this section is a detailed description of the procedures essential to a successful weld.

3.1.2 Reference documents applicable to this procedure are as follows:

V7-332002	LH ₂ Tank Assembly
V7-332442	LH ₂ Upper Center Cylinder Assembly (No. 4)
V7-332342	LH ₂ Upper Intermediate Cylinder Assembly (No. 5)
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Comp- onents, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem- Film
971-D-00265	Weld Schedule
TOS 556-005	Circumferential Sizing Tool
TOS 556-008	Turntable, Circumferential Welding
TOS 556-0027	Offset Measuring Tool, Circumferential Welding
MHP-C-87-S-II	Move LH ₂ Cylinders From T-7200001 to Saturn 1A
PRO 565-028	Circumferential Weld Cylinder 5 to Cylinder 4

3.2 POSITIONING CYLINDER 4 ON ROTATION TOOL

3.2.1 The positioning of Cylinder 4 onto the rotational support tool is a safety-critical item. The operation is performed by the riggers under the direction of a move coordinator. The detailed move procedures are documented in MHP-C-87-S-II. The responsibility for adherence to approved safety practices rests with Manufacturing.

3.2.2 Cylinder 4 is brought into Station 1A and lowered onto the rotational support tool (T-7204224). Twelve teflon-covered brackets support the cylinder at the lower edge (Figure 3-1).



Figure 3-1. Cylinder Supported on Rotation Tool

3.2.3 The cylinder is centered on the support pads by adjusting the two Teflon-protected screws on each of the support brackets. The space is equalized between the cylinder and all 12 clevises by tightening or loosening the adjusting screws on the inboard and outboard sides of the cylinder.

CAUTION

Do not use metallic bars or any tool which will scratch or mar the cylinder to pry the cylinder into the center position.

3.3 LEVELING CYLINDER 4 ON ROTATION TOOL

3.3.1 The cylinder is leveled on the rotation tool. The leveling tool (T-7204291) is clamped to the weld skate track. The indicator is adjusted so that the probe end is centered on the upper butt face of the cylinder. The dial indicator height is set to allow approximately 0.100-inch travel up or down and the dial face is set so the indicator reads zero.

3.3.2 The rotation tool and cylinder are checked for clearance before the tool is rotated. All electrical cords, hoses, cables, etc., must be stowed properly, away from rotating equipment.

3.3.3 The rotational control box is connected to the power panel on the first floor. (The control box safety key is removed from the control box when the tool is not in operation.) The speed control is set at 20-inches-per-minute travel. Personnel must stand clear while the turntable clearance is reverified.

3.3.4 The key is inserted in the control box and the turntable rotated while the dial indicator is monitored by a mechanic. The cylinder must be level within ± 0.030 inch (total indicator deflection 0.060 inch). Inspection will verify and clear FAIR book sequence if the cylinder is level within tolerance. If the cylinder is not level, the jack screws are adjusted at each support post. The high point of the cylinder as shown on the dial indicator is used as a base. The remaining points are raised to bring the cylinder into tolerance. The lock nuts on jack screws are tightened (Figure 3-2) and the cylinder level is verified within ± 0.030 inch. Inspection verifies and clears the FAIR book.



Figure 3-2. Leveling Cylinder



3.4 POSITIONING CYLINDER 5 ONTO CYLINDER 4

3.4.1 The mechanic positions the support saddles at 12 equally spaced points on the top edge of Cylinder 4. The saddles are checked for clearance before installation to be sure they do not scratch or mar the cylinders (Figure 3-3). This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has a responsibility to assure adherence to accepted safety practices. The move conductor will be in attendance during all phases of the move.

3.4.2 Cylinder 5 is loaded onto the saddles on Cylinder 4. Manufacturing personnel are positioned at six equally spaced areas to guide the bottom edge of Cylinder 5 into the saddles. The cylinder and handling fixture must be balanced to maintain a level plane within 1 inch during loading operations (Figure 3-4). This is a safety-critical operation.

CAUTION

Do not allow edge of cylinder to bump saddles or any equipment such as skate tracks.

3.4.3 The rotational alignment of the two cylinders is held by aligning Position I or the systems tunnel attach holes while the cylinder is lowered. Rotation need only be held within 1/2-inch at this time. The systems tunnel is approximately 6 feet counterclockwise from Position I.

3.4.4 The move conductor and Inspection clear all material-handling sequences in the FAIR book and clear all rigging equipment from station.

3.5 PREPARATION OF STATION FOR WELD OPERATIONS

3.5.1 The riggers move the bridge crane to the west end of the station and raise the curtain by means of a winch located on the first floor outside of the station. After the curtain has been secured, the air temperature is checked. The temperature in the weld station should be 76 F minimum. The humidigraph is located on the second floor; humidity reading in the weld station must not exceed 50 percent. If temperature or humidity exceed allowable tolerances, Maintenance is called to correct the condition.

3.5.2 The first and second floors are wet-mopped. The bench tops, bin tops, and exposed beams in the station are dusted. The operation of the shoe brush in the airlock entrance must be checked and the intercom system of phones on the inside and outside of the cylinder connected.

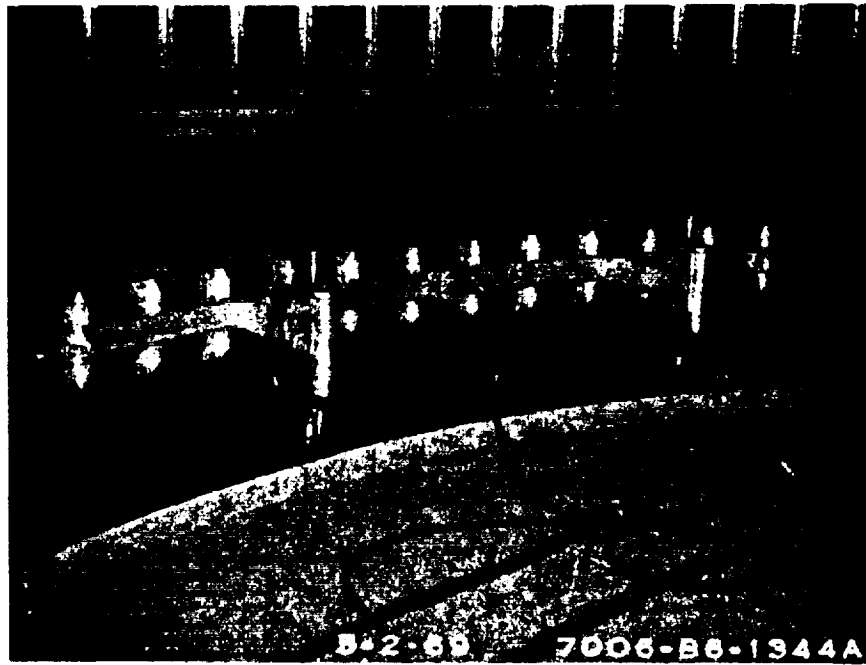


Figure 3-3. Vacuum Manifold

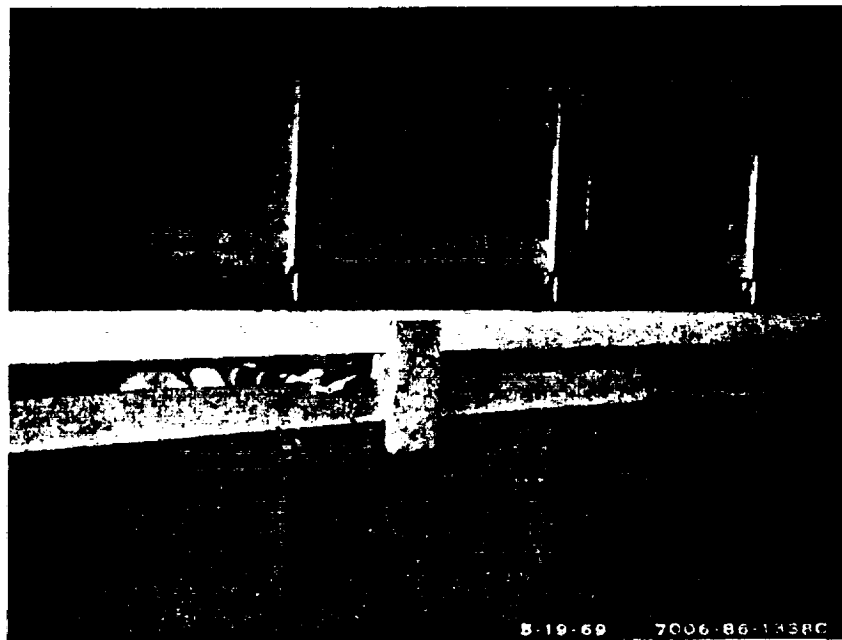


Figure 3-4. Cylinder Loaded Into Saddles



3.6 PREPARING CYLINDERS AND TOOLING FOR WELD

3.6.1 The dust is wiped from the face of the vacuum chucks of the circumferential sizing tool supports (T-7204223-401) using acetone and cheesecloth.

CAUTION

Acetone is highly flammable. Only approved containers and plastic bottles are used. Do not use acetone in open containers.

3.6.2 The mechanics lay the hydraulic manifold in position on the floor inside the cylinders and connect it to the pigtail leads of the rotating boom arm (Figure 3-3).

3.6.3 The chip catcher is positioned on the outboard side of the cylinder approximately 6 inches below the top edge. An aeroquip band is positioned around the cylinder and the upper flange of each section of the chip catcher is slipped under the band. When all sections of the trough are positioned another band is installed around the lower flange. Both bands are tightened by means of the built-in ratchet (Figure 3-5). The sheet metal chip catchers are laid on the web on the top inboard frame of Cylinder 4 (Figure 3-6).

3.6.4 One set of the lower vacuum chucks is located at the inboard wall of Cylinder 4. The top edge of the vacuum chucks must be kept level and 3 inches below the top frame (Figure 3-7). The first chucks on the end of the tool must be centered between the first and second vertical grids from the vertical welds on Cylinder 4. Three men are required to position the chucks (Figure 3-8). As the chucks are aligned to the cylinder, the vacuum line from the chucks is connected to the vacuum manifold and the line opened to secure the chuck. The chucks are tapped lightly to help seat them and prevent vacuum leaks (Figure 3-9). The 8 chucks are progressively aligned around the cylinder and the system is checked for vacuum leaks.

3.6.5 The spreader links are installed between the ends of the vacuum chucks. The ends of the spreaders are tied to the chuck frame by means of a ball lock pin in each end of the spreader links. The 8 spreader links are expanded by hand. This forms a full circle of the vacuum chucks and helps to support the chucks in case the vacuum supply fails (Figure 3-10).

3.6.6 The 8 safety poles are installed between the vacuum chuck frame and the base of the tool. The saddle end of the pole is positioned at the intersection of the center vacuum chuck bracket and the frame channel

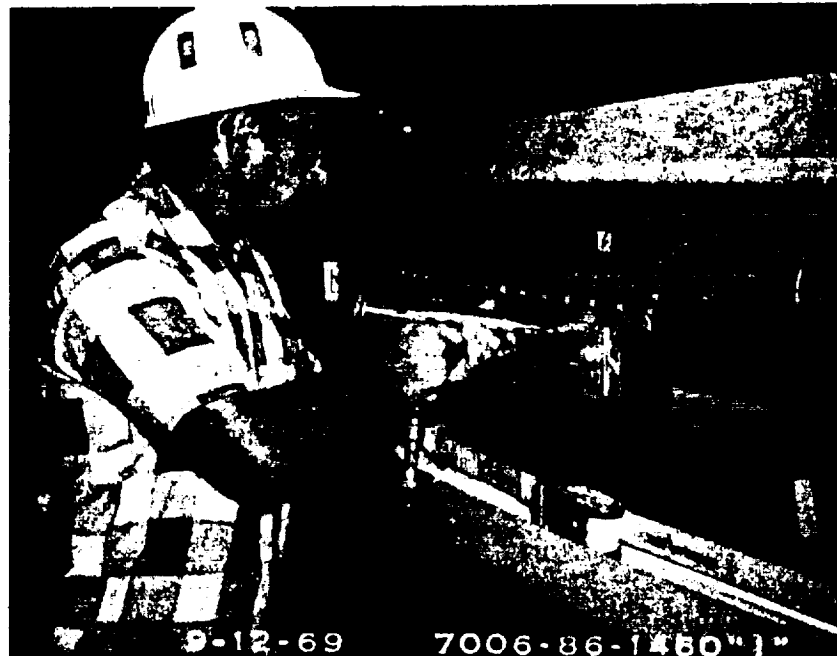


Figure 3-5. Chip Catcher Installation

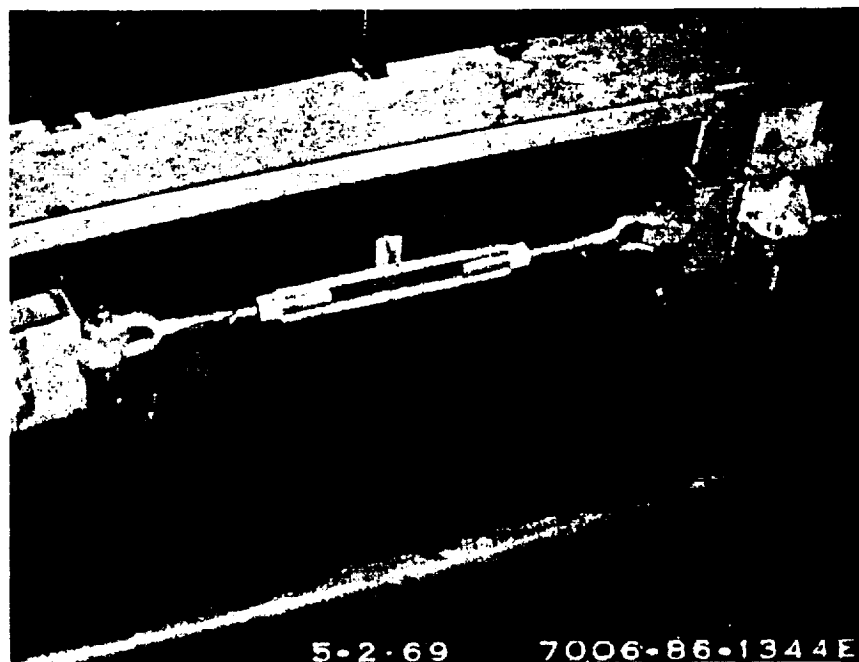


Figure 3-6. Inboard Chip Catcher Installation

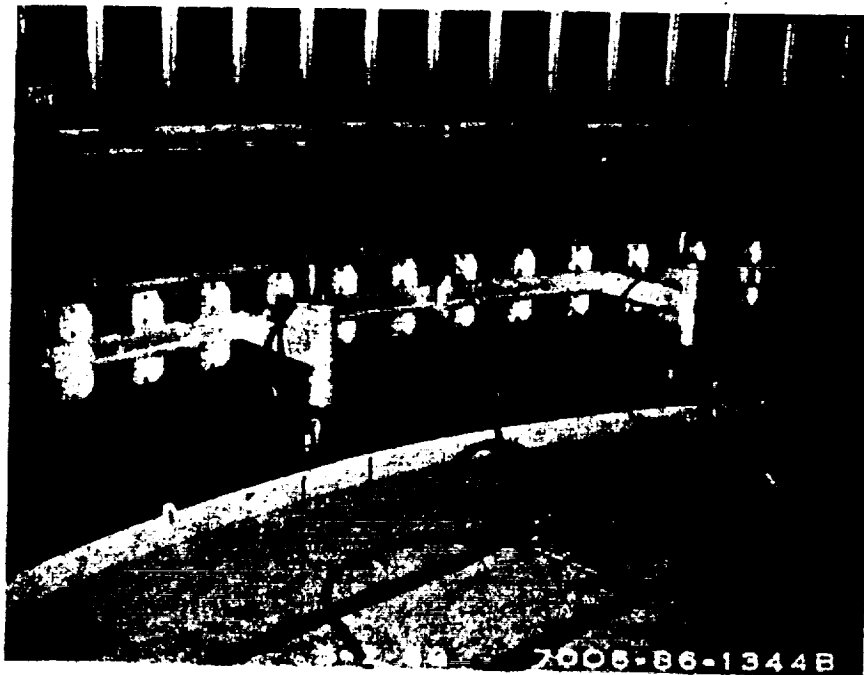


Figure 3-7. Alignment of Lower Vacuum Chucks



Figure 3-8. Positioning of Vacuum Chucks



Figure 3-9. Attachment of Vacuum Hose to Manifold

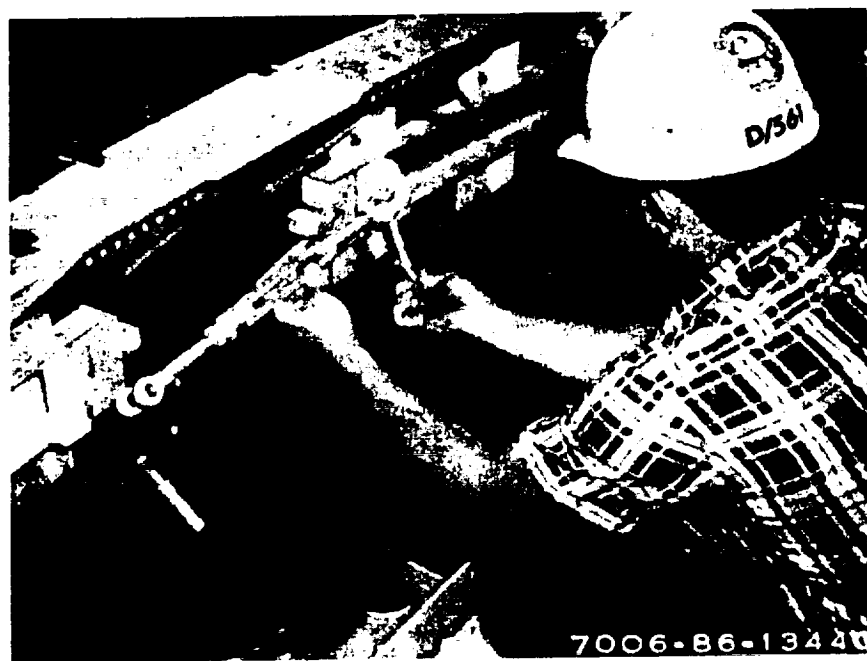


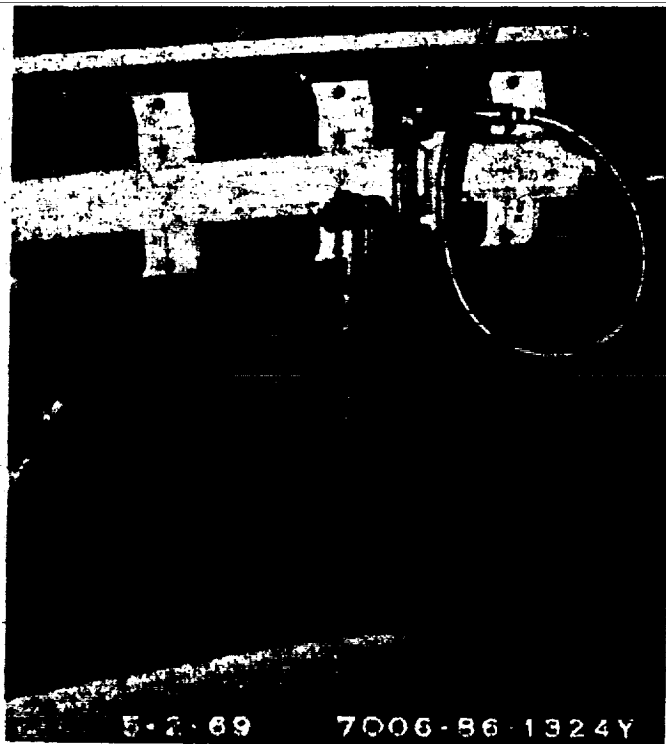
Figure 3-10. Installation of Spreader Links

(Figure 3-11). The support pole height is adjusted by loosening and retightening the slip joint at the center of support pole. The pole should fit snugly between vacuum chucks and rotation tool base.

3.6.7 The upper vacuum chucks are installed on Cylinder 5 directly above the lower chucks. The bottom edge of the chuck must be in a horizontal plane approximately 10 inches above the lower edge of Cylinder 5. As the chucks are aligned to the cylinder, the vacuum line from the chuck is connected to the vacuum line on the lower chucks by quick-disconnect fittings. The chucks are tapped lightly to seat the vacuum cups after applying vacuum. The hydraulic and vacuum lines on the inside of the cylinders are laid over the lower vacuum chuck supports (Figure 3-12).

3.6.8 The spreader links are installed between the ends of the upper vacuum chucks, using a ball lock pin in each end and also expanding them by hand. This forms a full circle of the upper vacuum chucks and helps support the chucks in case of vacuum failure (Figure 3-13).

3.6.9 The 16 control arms (A) are installed in the lower support chuck bearings (B) as shown in Figure 3-14. The horizontal arm (C) on top of the control arm is adjusted inboard and outboard by means of the adjusting screw (D) until the pin (E) can be installed through the upper vacuum support channel. The bolt (F) is loosened if necessary to allow the control arm to be



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Figure 3-11. Installation of Safety Poles



Figure 3-12. Installation of Upper Vacuum Chucks

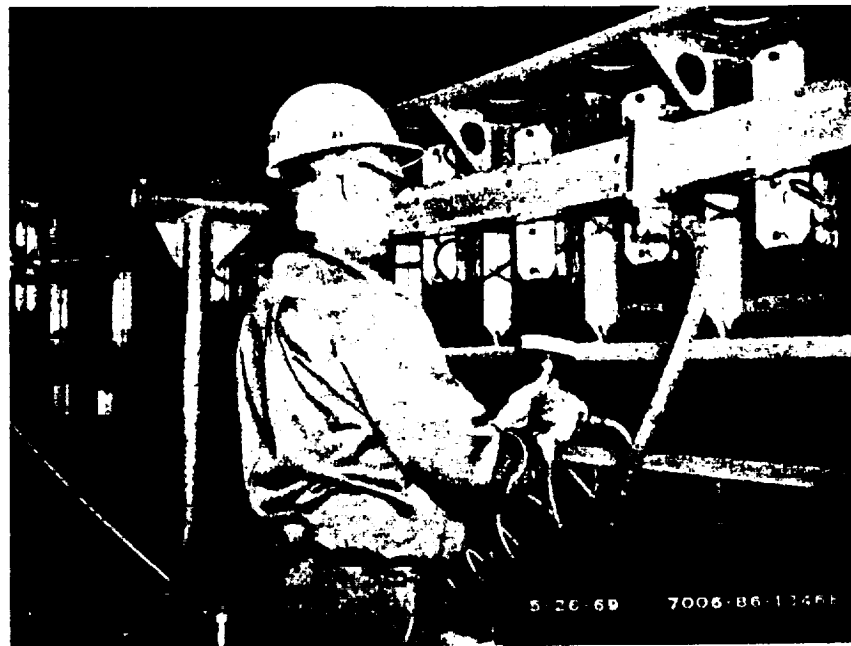


Figure 3-13. Spreader Links Installed

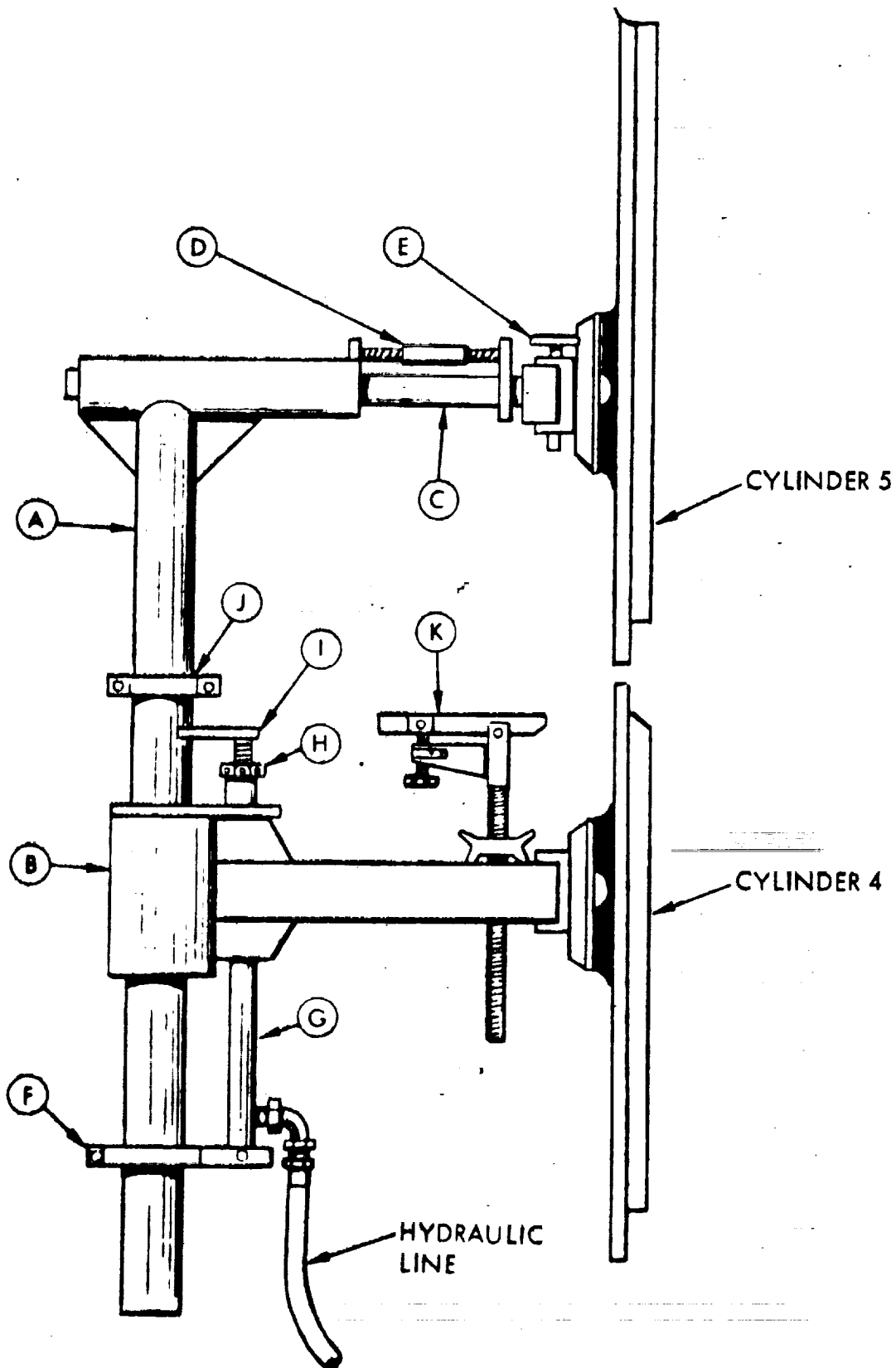


Figure 3-14. Sizing Tool Vacuum Chuck Supports



raised or lowered (Figure 3-15). The lines from the hydraulic cylinder (G) are connected to the manifold and rotating boom. With the clamp (F) still loosened, the hydraulic cylinder (G) is extended 12 inches. This setting is used with the cylinders resting in the support saddles. The clamp (F) on the control arm (A) is tightened (Figure 3-16). The spanner nut (H) is rotated until 1 inch of the thread shows between the spanner nut and the support plate (I). The clamp (J) is loosened and lowered until it rests on the support plate (I). The clamp (J) is then tightened (Figure 3-17). The 16 support posts are set using this procedure. The tooling and Cylinder 5 are checked for clearance before raising Cylinder 5.

3.6.10 The hydraulic reservoir is connected to the plant air supply. The sequence procedure posted on the hydraulic supply pump is followed to raise Cylinder 5 until a 6-inch gap exists between Cylinders 4 and 5 (Figure 3-18). The four safety blocks are clamped in place at the vertical welds (Figure 3-19).

CAUTION

The C clamps must be protected with foil or Teflon pads to prevent damage to the weld land. The spacer blocks must be washed with acetone prior to installing.

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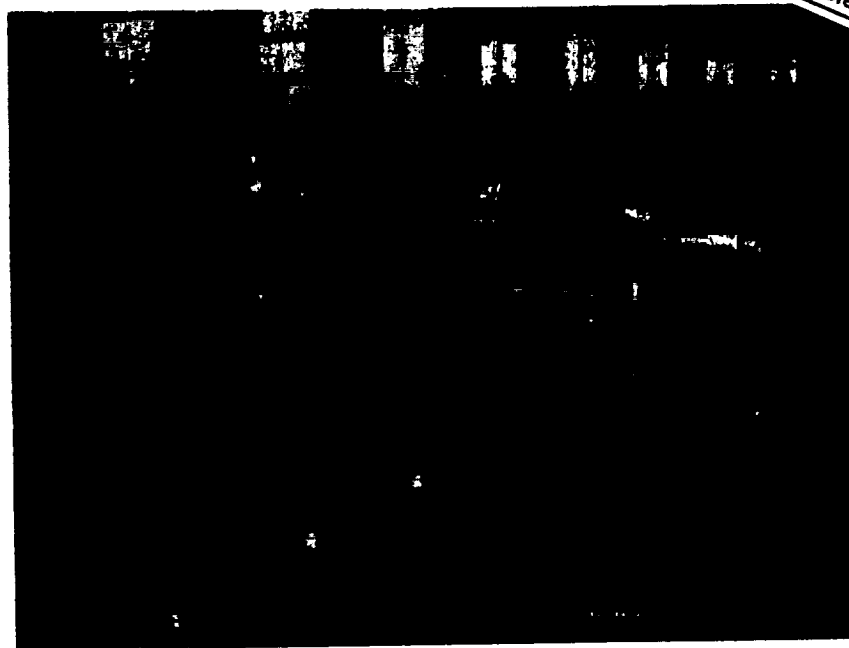


Figure 3-15. Control Arm Adjustment

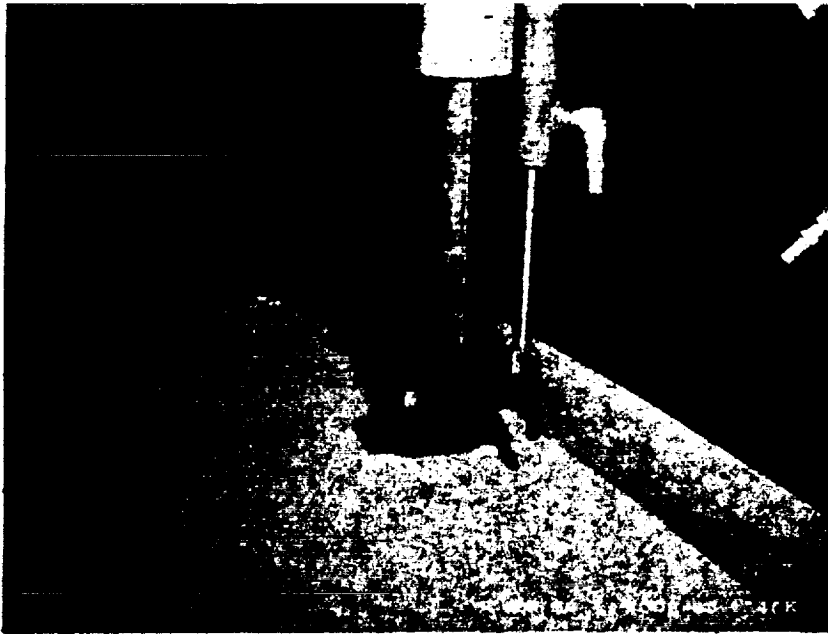


Figure 3-16. Clamp on Control Arm



Figure 3-17. Clamp-Support Plate Adjustment

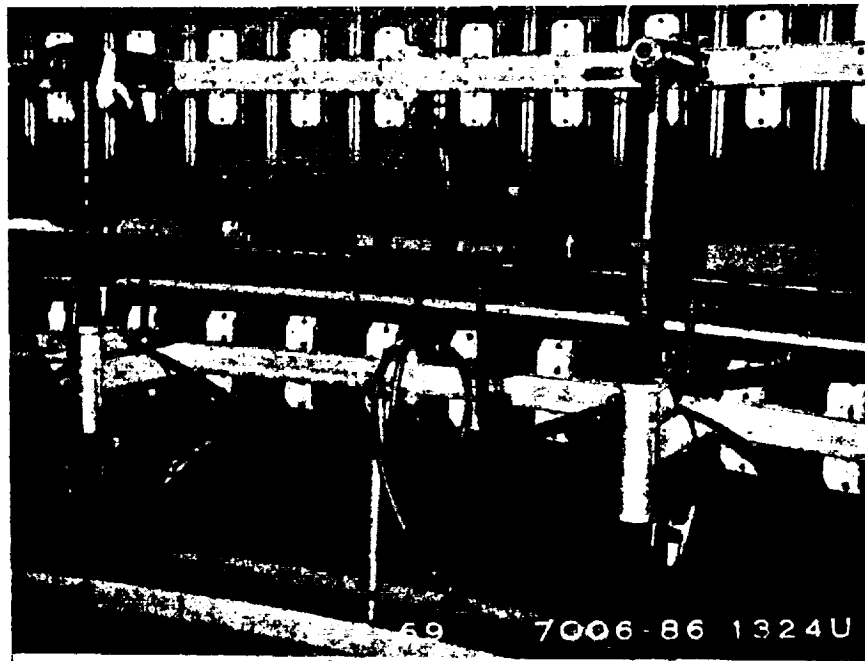


Figure 3-18. Cylinder Raised to 6-Inch Gap



Figure 3-19. Safety Block Installation



3.6.11 The numbered strip tape is applied below the weld land on the outboard side. The strip is numbered every 3 inches starting at zero. The zero mark is located at Position I on Cylinder 4 when applying the strip (Figure 3-20).

3.6.12 The 1-inch Mylar tape is applied 4 inches above the weld land to the inboard of Cylinder 5. The tape is applied between the vertical stringers around the entire circumference. The tape is marked in 3-inch increments starting with zero at Position I. The inboard marks must coordinate with outboard marks on Cylinder 4. If masking tape is used Mylar tape should be applied first (Figure 3-21).

3.6.13 The stringer end protectors are installed on the ends of the stringers of both cylinders.

3.6.14 Inspection checks the thickness on the weld lands on Cylinders 4 and 5 at each 3-inch increment. The measurements, taken with a micrometer, are logged on an ITI. Any out-of-tolerance areas which are undersize are submitted to Material Review for disposition. Areas which are oversize will be draw-filed to tolerance. The ITI is logged in the FAIR book.

3.6.15 The pi-tape readings of the Cylinder 4 and 5 circumferential weld lands are logged in the FAIR book by Inspection. These readings were taken previously in the bulkhead building after the cylinders were trimmed. Any dimensions out of tolerance will be submitted to Material Review for disposition.

3.7 VERIFICATION PANELS

3.7.1 These panels are run prior to preweld cleaning as described in Section 1.14.

3.8 PRECLEANING

3.8.1 Preweld cleaning operations are performed as described in Section 1.12.

CAUTION

Only personnel qualified for preweld cleaning are to clean the weld joint area.

3.8.2 The eight circumferential sizing tools are washed down with acetone using clean cheesecloth during the precleaning operation. The tools are checked for burrs on the fingers which come into contact with the weld lands.

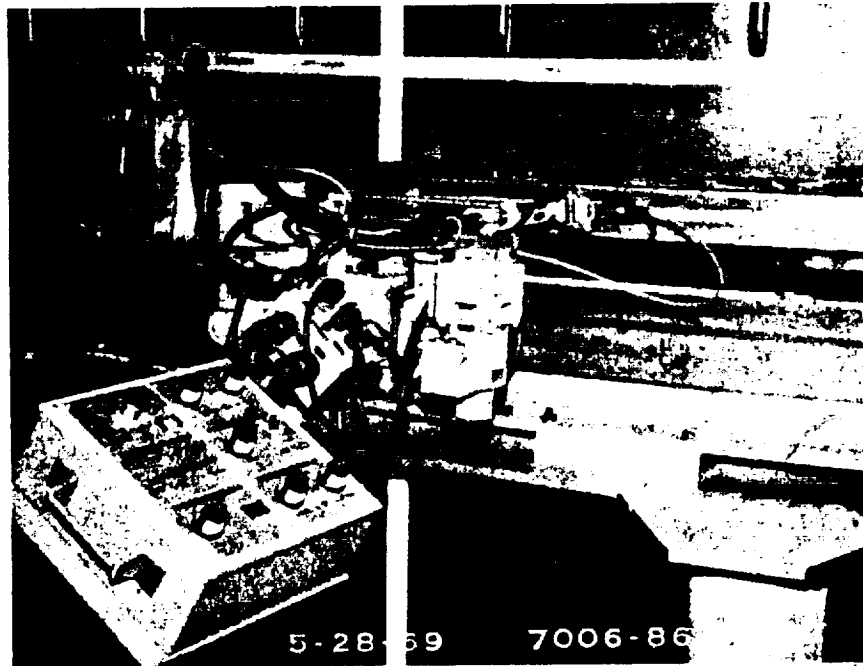


Figure 3-20. Installation of Tape (3-Inch Marked) Outboard

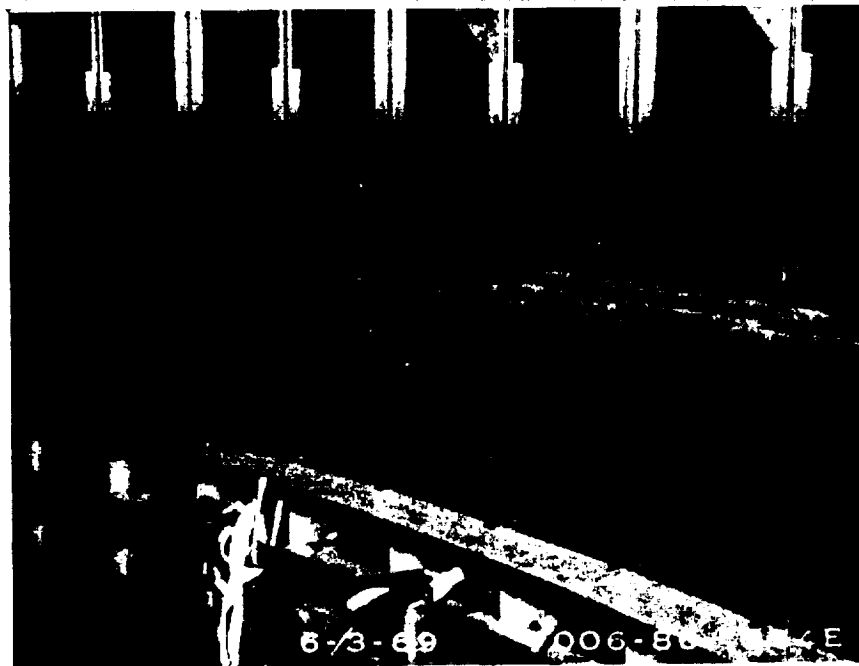


Figure 3-21. Marked Tape Installed Inboard



The defects are draw-filed with a mill file and washed with acetone and clean cheesecloth. The sizing tools are wrapped with kraft paper until ready for use.

3.9 WELD TOOLING SETUP

3.9.1 The 16 T-supports (K) are installed into the lower supports (B) as shown in Figures 3-22 and 3-23. The height is adjusted using the wing nut (L). The top of the crossbar is set 2 inches below the top edge of Cylinder 4.

3.9.2 The center T-supports are located on the channel by hooking them over the top flange of the channel. The set screw is then adjusted to level the top of the support. The height is adjusted by using the wing nut. The top of the crossbar is set 2 inches below the top edge of Cylinder 4. One of these supports is installed in the center of each of the bottom vacuum chuck assemblies (Figure 3-24).

3.9.3 After the precleaning of the cylinders is completed all chips are vacuum-cleaned from the area.

3.9.4 The circumferential sizing tools (T-7204223) are installed onto the T-supports using the hydrolift hoist. An adapter (T-7204223-903) is tied into the tools by means of three pins. Two of the pins are tied into the back flange of the tool and one through the center web. The -903 adapter is then tied to the hook of the hydrolift hoist located on the second-floor level on the inboard side of the cylinders. The turntable is rotated so that the first sizing tool can be set on the T-supports of the lower vacuum chucks (Figure 3-25).

CAUTION

The turntable and all hoses must be checked for clearance before rotating the table.

3.9.5 The first sizing tool is hoisted using the hydrolift and the arm is moved to position the tool on the T-supports and center the tool on the lower vacuum chucks (Figures 3-26 and 3-27). The turntable is rotated and the remaining seven sizing tools are moved into position.

3.9.6 The spreader jacks (T-7204223-381) are installed between the sizing tools at 8 places. The spreaders are attached by means of 1/2-inch-diameter ball lock pins through the slotted holes. It may be necessary to pry the last two bars apart to install the last spreader jack. A turnbuckle placed between the ends of the sizing tool and then expanded will force the tools apart enough for the spreader jack to be installed. Do not allow tools to contact the cleaned butt edges of the cylinders (Figure 3-28).

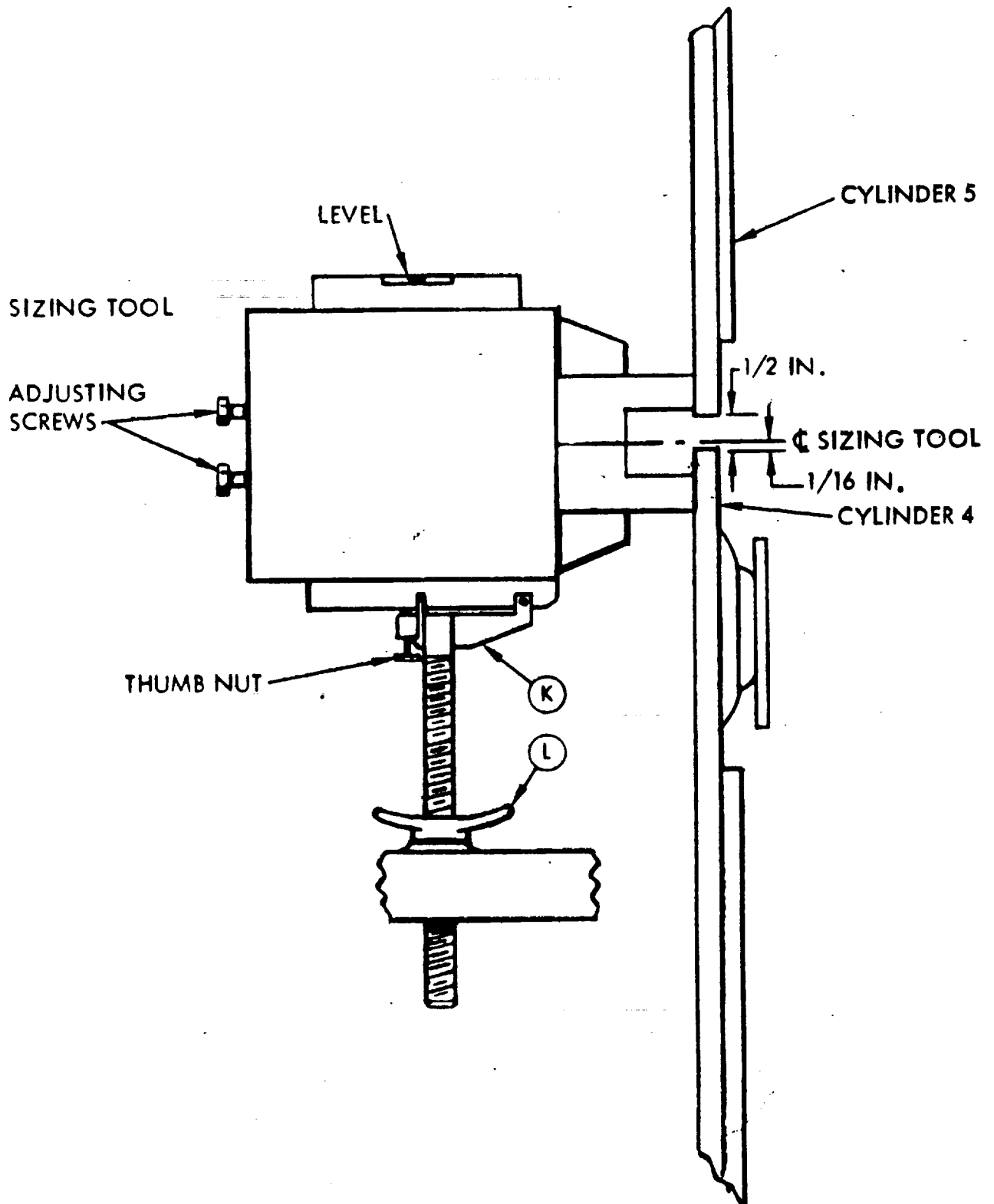


Figure 3-22. Height Adjustment.



Figure 3-24. Center Supports for Sizing Tool



Figure 3-23. Sizing Tool T Supports

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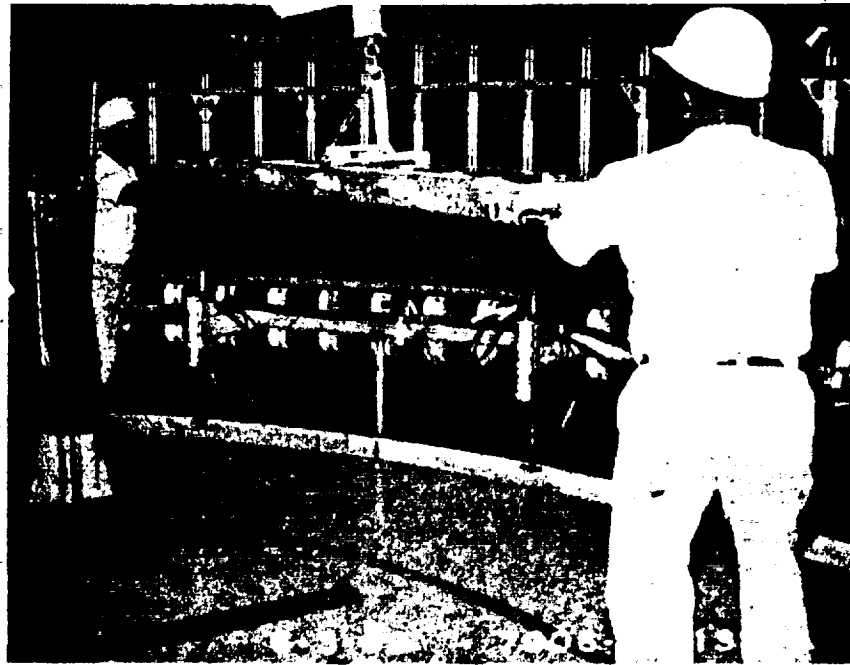


Figure 3-25. Hoist Positioning Sizing Tool



Figure 3-26. Sizing Tool Moved Onto Lower Vacuum Chucks

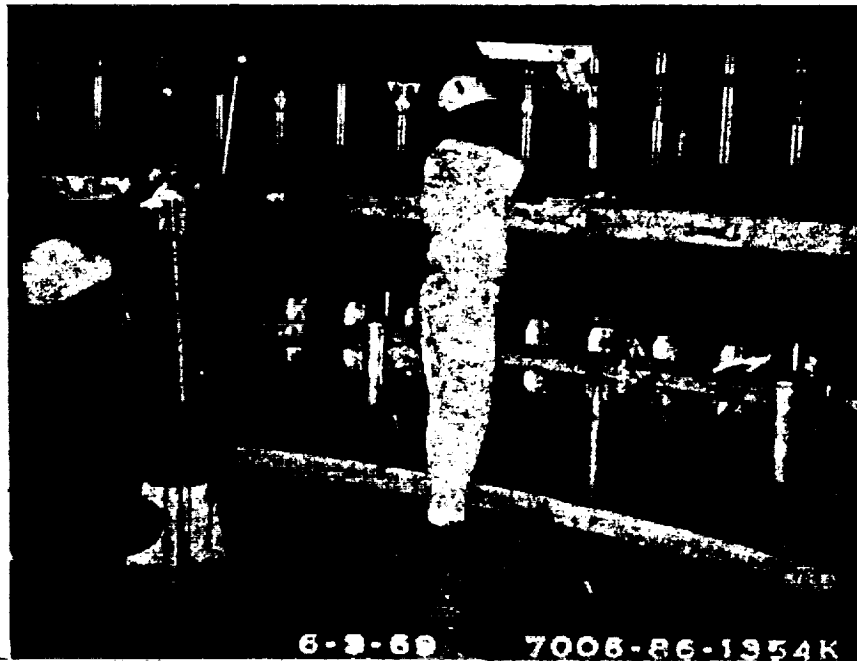


Figure 3-27. Centering Tool on Vacuum Chucks

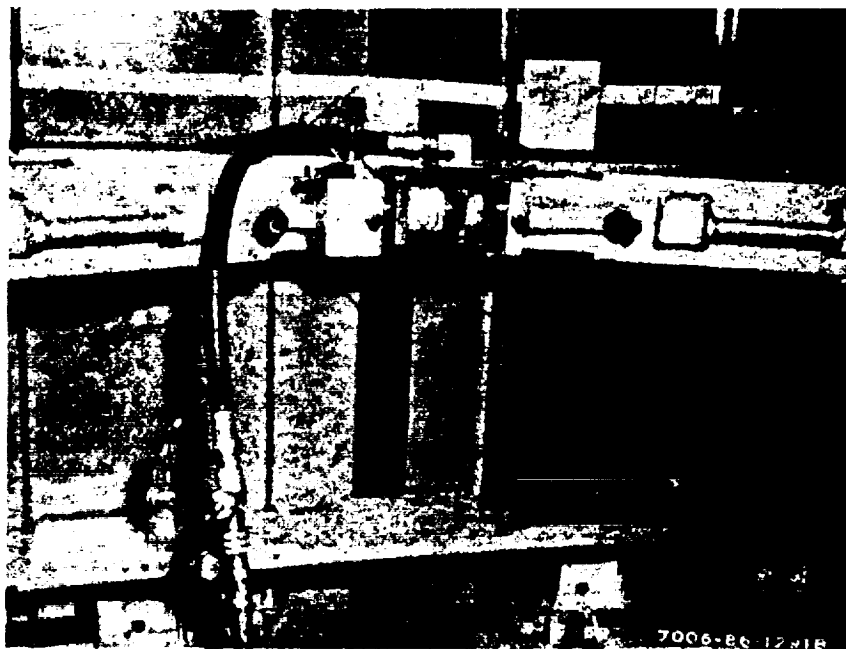


Figure 3-28. Spreader Jack Installation



3.9.7 The dust cups are removed from the ends of the hydraulic lines attached to the spreader jacks, the lines are connected to the hydraulic manifold and the valves are opened. If the spreader jacks have not previously been wrapped in plastic, it is wrapped around them to prevent hydraulic oil from contaminating the cleaned weld surface in case of hydraulic oil leaks.

3.9.8 The top edge of Cylinder 4 must be within 1/16-inch below the center line of the circumferential sizing tool (Figure 3-22). The height of the sizing tool is adjusted by means of a wing nut (L). A spirit level is set on top of the sizing tool and the tool is leveled by means of the thumb nut on the support (K) (Figure 3-22).

3.9.9 Cylinder 5 is lowered over the sizing tools, employing the hydraulic jacks (G) in Figure 3-14, until a 7/16- to 1/2-inch gap exists between Cylinders 4 and 5. Clamp J should rest on I at the 16 locations around the circumference.

CAUTION

Follow instructions posted on the hydraulic console for lowering Cylinder 5. Only qualified personnel are to operate pump. Use extreme care in lowering and continually check around circumference so that the butt face of the Cylinder 5 does not contact the sizing tool fingers.

3.9.10 The hydraulic system is pressurized to 3000 psig to expand the circumferential sizing tools. The instructions displayed on the hydraulic console must be followed. The operation should occur near a shift change. The joint is covered with aluminum foil inboard and outboard, using only approved tape. Do not contaminate joint area.

3.10 FINAL CLEANING OPERATION

CAUTION

All personnel must wear clean white smocks, caps, and nylon gloves during this operation.

3.10.1 The aluminum foil is removed from the weld joint, and the joint is cleaned as defined in Section 1.12 of this volume.



3.11 FINAL WELD PREPARATION

3.11.1 The rotational alignment tool (T-7203708) is installed after completion of final cleaning. The tool attaches to two of the tunnel attach holes (left-hand) in Cylinder 5 and two of the holes (left-hand) in Cylinder 4. The tool is provided with 1/4-inch inside diameter and 3/4-inch outside diameter bushings and special 1/4-28 screws. The bushings and screws are slipped through the holes in the alignment tool. One hole in each half of the tool is slotted vertically to allow for the tolerance in the tunnel attachment holes (Figure 3-29).

3.11.2 Pressure in the sizing tool is lowered to 500 psig. Precleaned, 0.040-inch stainless steel shims are installed at 12 equally spaced points and around the circumference of the cylinders. The spacers are taped to Cylinder 4 below the cleaned area with Mylar tape. One leg of the shim, approximately 1/2 to 3/4-inch long, must rest on Cylinder 4 butt edge (Figure 3-30). These shims are used to prevent Cylinder 5 from bearing on Cylinder 4 during the lowering and rotational alignment operations.

CAUTION

The shims must be precleaned with acetone prior to installing. Do not contaminate the shims during installation. Only approved tape is to be used on the cylinder surface.

3.11.3 Cylinder 5 is lowered by the use of a spanner wrench on the nuts (H) shown in Figure 3-14. The cylinder is progressively lowered by turning the nuts counterclockwise on the 16 support jacks (G). The lowering operation is monitored from the outboard side of the cylinders. The rotational alignment of the cylinders is checked during lowering.

3.11.4 Cylinder 5 is lowered to approximately 1/8-inch gap around the circumference. The rotational alignment is checked by means of the pointer on the upper alignment tool against the scale on the lower tool. Tolerance must be kept within 0.030 inch. The sizing tool pressure may have to be lowered to zero and Cylinder 5 rotated by personnel pushing from inside the cylinder. In extreme cases a cable hookup and turnbuckle can be used for rotation purposes.



Figure 3-29. Rotational Alignment Tool Installed

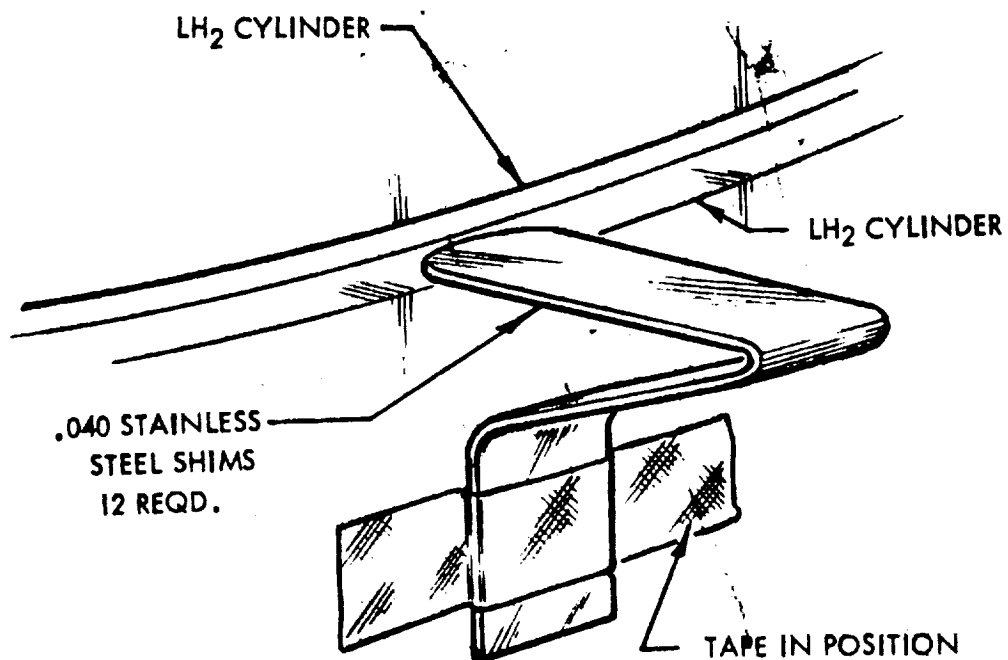


Figure 3-30. Stainless Steel Shims Installed



3.11.5 The sizing tools are repressurized to 500 psi if the pressure has been lowered for rotation. Cylinder 5 is lowered at Position No. 1 to approximately an 0.040-inch gap. Rotational alignment is checked and sizing tools are pressurized to 6000 psig.

CAUTION

Only qualified personnel are to operate the hydraulic pump. Rotational alignment must be verified by inspection and the item cleared in the FAIR book.

3.11.6 Approval to weld is verified in the FAIR book.

3.11.7 The welders and the weld engineers verify the equipment during the final cleaning operation. The gas is checked, and the heat treat number, size, etc., are logged in the FAIR book. A bead-on verification plate is run and submitted to Quality Control, which also checks the machine settings to 971-D-00265 Weld Schedule. The weld heads are then moved to the skate track at each weld position. The welder hooks the sensing and ground leads to the assembly, and these are then checked by the weld engineer (Figure 3-31).

3.12 WELDING OPERATIONS

3.12.1 Each of the two tack weld teams utilized for the circumferential welds consist of a welder, an offset manipulator, and a vacuum hose operator for outside the cylinder, and an offset manipulator on the inside. The teams operate 180 degrees apart. Another team for each weld station consisting of a man on the outboard side and a man on the inboard side, preset the offset ahead of the tacking crew. The weld machine parameters are set for the intermittent tack weld per 971-D-00265 Weld Schedule.

3.12.2 Communication between the outboard and inboard side is by means of intercom headsets. The outside mechanic checks the offset using a 0.050-inch thick stainless steel gauge and informs the man on the inboard side which cylinder must be moved to arrive at a target of 0.010-inch offset. The inside man adjusts the offset by means of the bolts on the inboard side of the circumferential sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers (Figure 3-32).

3.12.3 The first tack is located at approximately Position I, where a 0.040-inch gap exists. The offset is set by the manipulating team. The joint area is vacuumed to remove any foreign material from the faces of the cylinders; care is taken not to touch the surfaces. The weld head is then

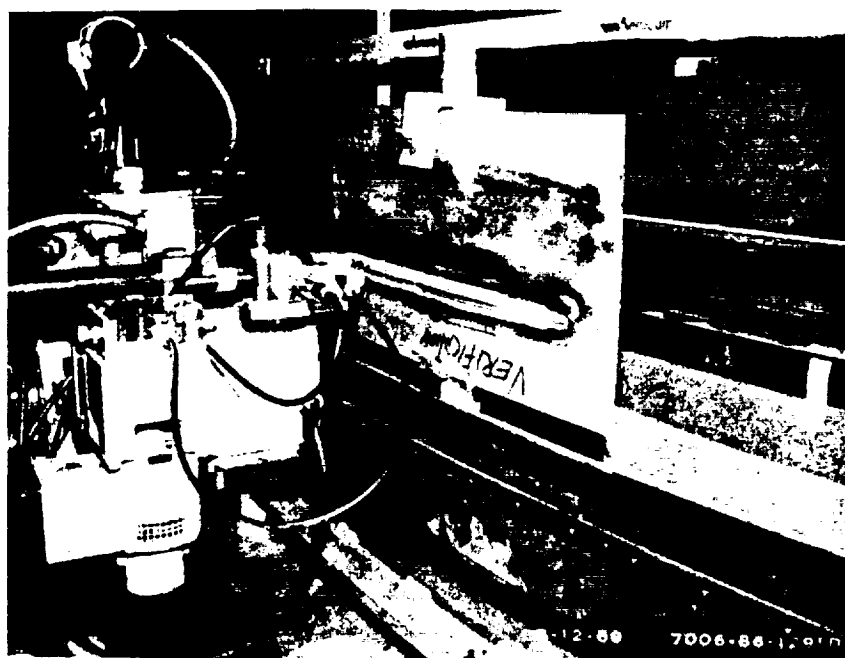


Figure 3-31. Verification Plate



Figure 3-32. Offset Adjustment



moved into position for the first tack, and locked to the gear racks on the tracks. The torch is positioned for the tack and the circumferential sizing tool pressure of 6000 psi verified. The first tack is made. A 3-inch long tack is run per 971-D-00265 and the machine tapered out. A space of 6 inches is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for four or five tacks. The rotational alignment tools and the 0.040 stainless steel shims then are removed.

3.12.4 The gap around the cylinders is checked and if the gap 180 degrees from the first tacks exceeds 0.040-inch, the circumferential sizing tool pressure is lowered to 500 psi. Cylinder 5 is then lowered to a 0.040-inch gap. If required the cylinders can be pulled together by means of a large clamping tool (Figure 3-33). The circumferential sizing tools are pressurized to 6000 psi.

3.12.5 The tacking operation can begin at the second weld position when the gap is determined to be 0.040-inch at Position III (180 degrees from the first tacks). The same offset alignment procedure is used.

3.12.6 The cylinders are progressively tack-welded at the two weld stations with 3-inch long tacks at 9-inch centers. When each weld machine has tacked the cylinders the full length of the skate track, approximately 8 feet, the turntable is rotated to allow a second series of tacks. The turntable is rotated to a new tack position 7 times. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.015-inch offset after welding is checked by supervision and reworked if required.

3.12.7 The circumferential sizing tools are checked for centering. The pressure is dropped to recenter the tools if required and repressurized to 6000 psig after recentering. All the adjusting screws must be backed off and then readjusted finger-tight to assure contact of the circumferential sizing tools with the cylinders.

CAUTION

Do not over-tighten screws.

3.12.8 The weld machine parameters are checked for the continuous-tack pass per 971-D-00265. Using the procedures described in Section 1.14, a bead-on plate is run.

3.12.9 The turntable speed is set on the turntable control box and the direction of travel checked. The turntable travel is in a clockwise direction.

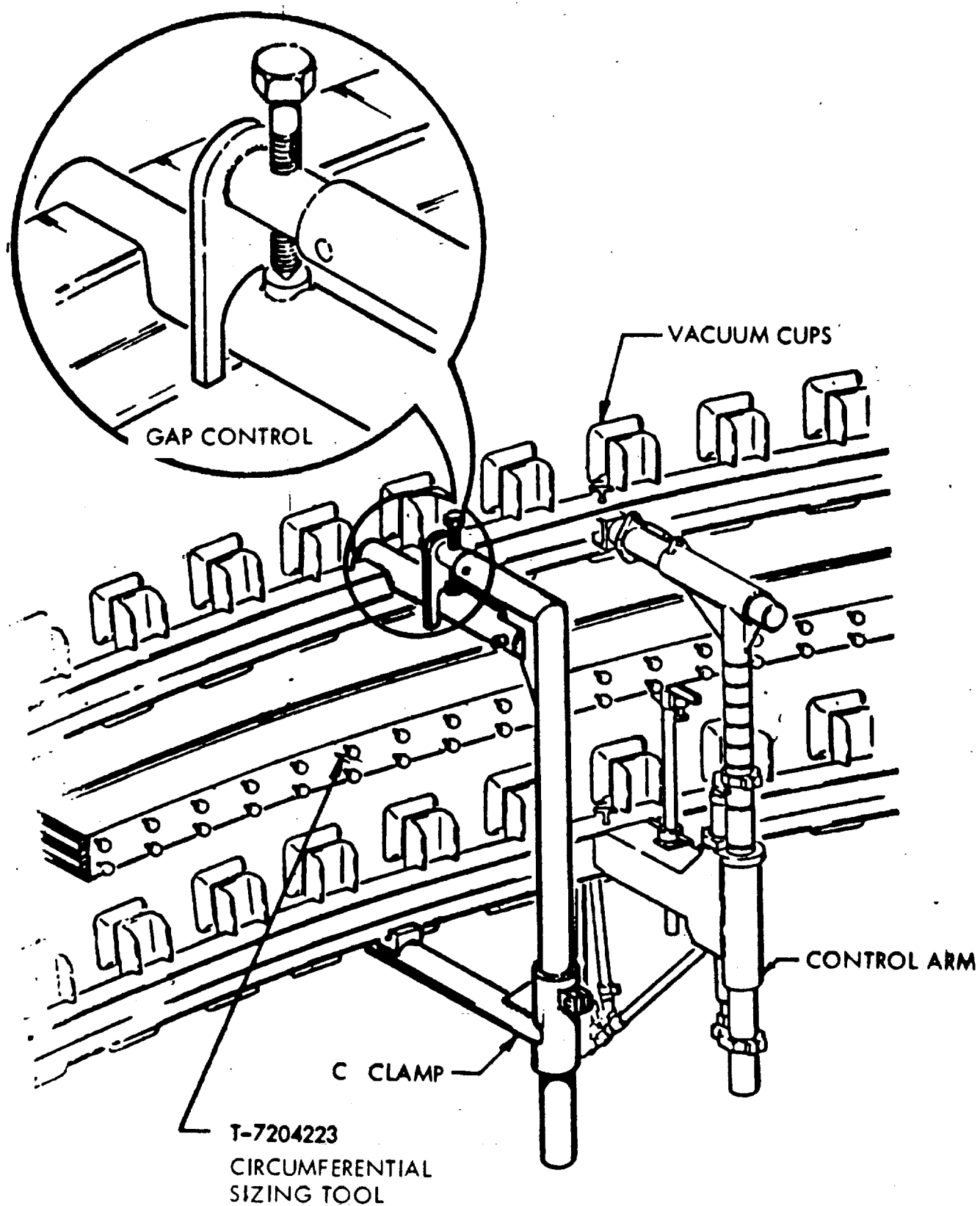


Figure 3-33. C Clamp for Drawing Cylinders Together



An air motor with a 1/4-inch ball rotary file is set up at each weld station. This is used to grind out the minute crater cracks left when the weld machine sequences out after running the continuous-tack pass.

3.12.10 The weld heads are positioned at the right-hand end of the skate tracks, allowing sufficient distance from the end to permit the skate travel to sequence out the weld heads in the event the turntable malfunctions. Weld heads are locked into the track and the travel potentiometer set for the correct skate speed. In the event the turntable stops, the welder must immediately switch on the skate travel switch and then sequence out. A final check is made on turntable speed, direction of travel, weld machine settings, skate-to-track lock, and circumferential sizing tool pressure. A countdown is called out on the intercom and, at the words "sequence start", both welders energize their weld machines. As soon as both arcs stabilize, the turntable is started. In the event one machine fails to start, two courses are open to the supervisor or weld engineers: the operating machine can continue while the second machine is checked out for the cause of misfire and then fired in a running start, or the operating weld head can be sequenced out until the second machine is checked and then both machines restarted together.

3.12.11 The continuous tack pass is performed per 971-D-00265. Each machine overlaps the start of the other machine for a minimum distance of 6 inches or until a good tie-in is made. As each machine sequences out for any reason, the tailout crater is ground out to a depth of approximately 0.060 inch with the ball rotary file. The crater is ground out as soon as the welding arc is terminated so that any small cracks do not propagate.

CAUTION

Do not shut off turntable until both machines have sequenced out.

3.12.13 The circumferential sizing tools again are checked for centering and adjusted as needed as the cover tack pass cools down. If the tools are moved, they are repressurized to 6000 psi.

3.12.14 The entire cover tack pass is brushed using a fine stainless steel rotary brush in an air motor. The brush is moved in long strokes in one direction only. The dust and soot are vacuumed from the area. The surface must not be touched with any material except the wire brush.

3.12.15 The weld machine parameters are reset for the penetration weld pass per 971-D-00265.

3.12.16 The current override control is moved to the inside of the cylinder, and the control switch of the weld pack turned on. (Figure 3-34).

3.12.17 Phone communications between inboard and outboard at each weld station are checked. The turntable speed is set for the penetration pass on the control box and rechecked for direction of travel. The turntable travel will be in a clockwise direction. Availability of the air motors with 1/4-inch ball rotary file is verified. The position and centering of the circumferential sizing tools are rechecked. Before start of the penetration pass the operators on the inboard side must be in position and in contact with the welder on the outboard side by means of the phones.

3.12.18 The countdown is started and at sequence start both machines are energized. When the arcs stabilize, turntable rotation is started. The operator on the inboard side controls the amount of drop through on the penetration pass and also is responsible for tracking the seam. The drop-through is watched by means of sight holes in the circumferential sizing tools (Figure 3-34).

CAUTION

The cables on the inboard side are checked as the boom rotates so they do not hang up.

3.12.19 The penetration pass is performed per the 971-D-00265 Weld Schedule. Both machines overlap the start of the other machine for a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground out to a depth of approximately 0.060 inch and checked to assure that all tailout crater defects are removed.

3.12.20 The drop-through is checked for incomplete penetration. If a defective area exists, it is rotated to the closest weld head. This weld can be picked up by either weld machine using the skate travel of the head instead of the turntable rotation.

3.12.21 White garments are not required for the following operations.

3.12.22 After the penetration pass or pickup operations are complete, the circumferential sizing tool pressure is dropped. The 8 circumferential sizing tools spreader jacks are removed and stored neatly on the inboard side of cylinders. The 8 upper vacuum chucks and the 16 support arms are removed and stored on the first floor tooling carts.

3.12.23 The stringer end protectors are reinstalled on the ends of the stringers of both cylinders (Figure 3-35). The turntable is checked to assure

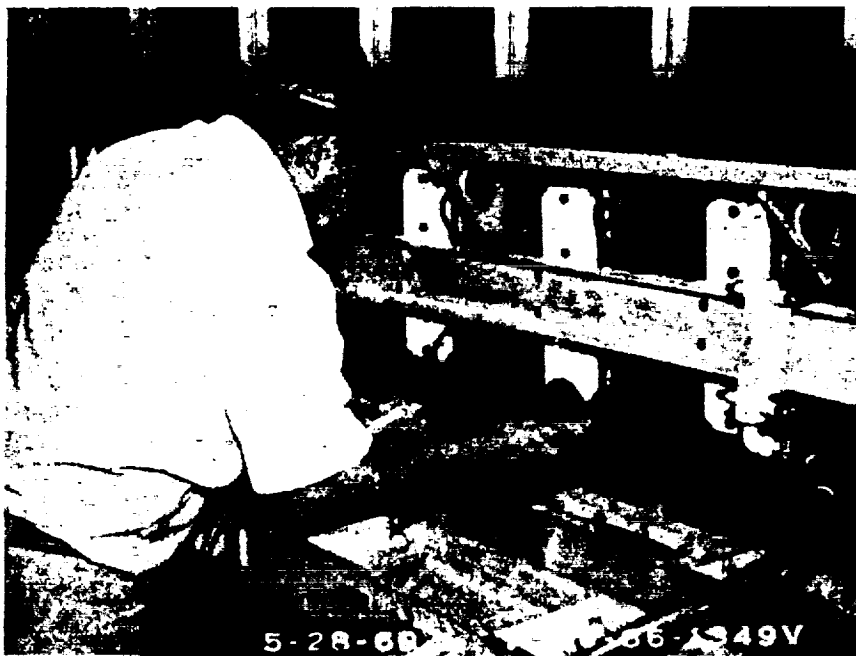


Figure 3-34. Use of Override Control

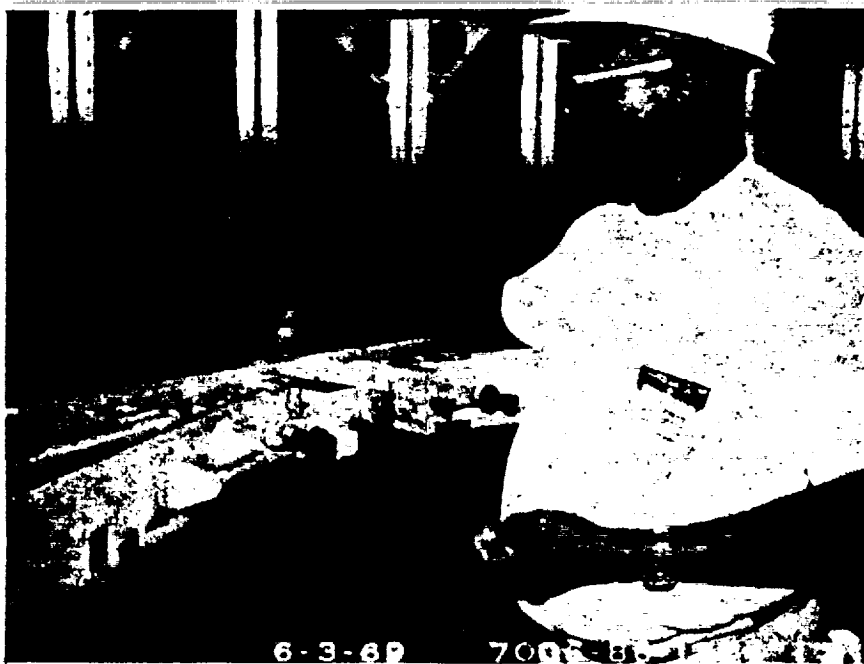


Figure 3-35. Installation of Stringer End Protectors



clearance and rotated to position a circumferential sizing tool at the hydro-lift. The hydrolift with the adapter (T72044223-903) is used to remove the first circumferential sizing tool and lower it to the floor. The turntable is rotated progressively to remove the remaining 7 tools.

CAUTION

Do not remove the lower chucks at this time.

3.12.24 The drop-through side of the weldment is inspected for undercut, incomplete penetration, fold, etc. The inspector verifies the drop-through, usually by means of a reference squawk. The weld bead is milled on the inboard side using three or four weld shavers. The bead is milled to a height of 0.010 to 0.015 inch with care being exercised that the shaver blades do not cut the parent material (Figure 3-36).

3.12.25 The weld bead is then smoothed using a Bear-Text wheel in an air motor. The air motor should be used with long, even-pressured strokes, not pausing in any one area, which causes high and low spots. The Bear-Text wheel must not be run crosswise or at an angle to the weld (Figure 3-37).

3.12.26 A fine stainless steel rotary brush mounted in an air motor is used to remove the soot from the outboard of the weld. This side is checked for any folds or minor surface defects which can be blended out prior to X ray. The blending is performed with a ball rotary file. The inboard and outboard sides are washed using clean cheesecloth and acetone.

3.12.27 The inspectors X-ray the weld and prepare the report. Any defects identified are evaluated by the Manufacturing supervisor and weld engineer to determine which should be reworked prior to putting the cover passes on the weld. A Manufacturing Request for Rework (Form 0121-S) is filed requesting planning tickets for in-process rework.

3.12.28 The defects are reworked following the procedures given in Section 10.

3.12.29 The circumferential sizing tools are reinstalled when rework is complete, using the procedure outlined for the first installation. The system is pressurized to 6000 psig and checked for hydraulic leaks. The following operations require white garments.



Figure 3-36. Milling Weld Bead



Figure 3-37. Abrading Weld Bead With Bear-Tex Wheel



3.12.30 With a clean fine stainless steel rotary brush in an air motor, the outboard side of the weld is wire brushed and then wiped with acetone and cheesecloth.

CAUTION

The wire brush is moved in long strokes in one direction only.

3.12.31 The weld machine parameters are reset per the 971-D-00265 Weld Schedule for the cover pass. The turntable speed is set for the cover pass and the direction of the travel is checked. The turntable travel is in a clockwise direction. The override control remains off. The availability of the air motors with 1/4-inch ball rotary file is verified. The position and pressure of the circumferential sizing tools are checked.

3.12.32 The countdown is started and at sequence start both machines are energized. When arcs stabilize turntable rotation is started and the first cover pass is run. The operator makes sure that the bottom edge of the penetration pass is covered by the first cover pass and overlaps cover passes at least 6 inches before sequencing out.

3.12.33 The sequence-out crater is ground out with the rotary file. The cover pass is wire brushed and inspected for lack-of-fill areas. It is decided at this time whether a complete second pass should be run or only intermittent pickup passes made.

3.12.34 The second cover pass is made using the same operations as the first cover pass. If intermittent pickups are required, the turntable or the skate track is used depending upon the length of the area. After the second cover pass or intermittent pickups are made, the weld is inspected for defects.

3.12.35 The stringer end protectors are again installed on the end of the stringers of both cylinders (Figure 3-21). The circumferential sizing tools and the lower vacuum chucks are removed.



3.12.36 Three or four weld shavers are used to mill the cover passes to 0.010- to 0.015-inch height. Care must be exercised so the parent material is not cut. The weld bead is polished using a Bear-Text wheel moved in long strokes in one direction only.

CAUTION

Do not brush across the weld.

3.13 POST-WELD OPERATIONS

3.13.1 X-ray personnel X-ray the entire weld. The film is read out and triangulation shots made of any questionable areas. Rework, if required, is accomplished by the in-process method per Section 10, or by MR action. After X ray is complete, fluorescent penetrant inspection of the joint, both inboard and outboard, is performed. Manufacturing personnel assist fluorescent-penetrant inspection by blending out defects if they do not lie below parent material thickness.

3.13.2 Inspection clears the sequences in the FAIR book after the X-ray and fluorescent-penetrant inspections are completed.

3.13.3 The inboard and outboard sides of the weld are Chem-filmed using the following operation.

3.13.4 The weld land is wiped with acetone on a cheesecloth pad.

3.13.5 The area is de-oxidized abrasively using Bear-Text pads rubbed lightly by hand. The area is wiped clean with a cheesecloth pad. The Chem-film solution is applied by a mechanic using rubber gloves. The excess solution is removed after 3 to 5 minutes using a cheesecloth pad and deionized water. After the Chem-film has dried for a minimum of 12 hours black vinyl tape is applied. Inspection verified the Chem-film operation in the FAIR book.

4.0 CYLINDER 4 TO CYLINDER 3 CIRCUMFERENTIAL WELD

4.1 GENERAL DESCRIPTION

4.1.1 The techniques and procedures utilized in circumferential welding of Cylinder 3 to Cylinder 4 are described in this section. This operation is performed in Station 1A with Cylinder 3 mounted on the tool (T-7204224) as shown in Figure 4-1. The cylinders are rotated and the two weld heads held stationary. Weld joint offset is controlled by an internal circumferential sizing tool (T-7204223). Included in this section is a detailed description of the procedures essential to successful welding of this joint.

4.1.2 Reference documents applicable to this procedure are as follows:

971-D-00265	Weld Schedule
V7-332002	LH ₂ Tank Assembly
V7-332542	LH ₂ Lower Central Cylinder Assembly (No. 3)
V7-332442	LH ₂ Upper Center Cylinder Assembly (No. 4)
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-Film
TOS 556-005	Weld Backup Bar Circumferential Welding
TOS 556-008	Turntable Circumferential Welding
TOS 556-0027	Offset Measuring Tool Circumferential Welding
MHP-C-87-S-II	Move LH ₂ Cylinders from T-7200001 to Station 1A
MHP-C-88-S-II	Move LH ₂ Cylinders from Storage to Station 1A
MHP-C-89-S-II	Move LH ₂ Cylinders from T-7200001 to Station 1A
PRO 565-029	Circumferential Weld Cylinder 4 and Cylinder 5 Assembly to Cylinder 3



4.2 POSITIONING CYLINDER 3 ON ROTATING TOOL

4.2.1 The Material Handling group removes the Cylinder 4-Cylinder 5 assembly from the assembly tool (T-7204224) and stores it on a handling dolly.

4.2.2 Cylinder 3 is loaded onto the rotation tool (T-7204224) in Station 1A. This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has the responsibility to assure adherence to accepted safety practices. The move conductor must be in attendance during all phases of the move.

4.2.3 The riggers load the cylinder on the fixture with an overhead crane. The detailed procedures are covered in the MHP-C-87-S-II. The lower edge of the cylinder is positioned on each of the Teflon-covered clevises supported on 12 brackets (Figures 4-1 and 4-2).

4.2.4 The cylinder is centered on the support pads by adjusting the two Teflon-protected screws on the support brackets. The space between the cylinder and the 12 clevises is equalized by manipulating the adjusting screws on the inboard and outboard side of the cylinder.

CAUTION

Do not use metallic bars or any tool that will scratch or mar the cylinder to pry the cylinder into the center position.

4.3 LEVELING CYLINDER 3 ON ROTATING TOOL

4.3.1 The cylinder is leveled on the rotation tool. The leveling tool (T-7204291) is clamped to the skate track, and the dial indicator is adjusted so the probe end is centered on the upper butt face of the cylinder. The dial indicator height is set to allow approximately 0.100 inch of travel up or down. The dial face is set to zero (Figure 4-3).

CAUTION

Before rotating, the rotation tool and the cylinder are checked for clearance. Verification is made that all electrical cords, hoses, cables, etc., are stowed away from rotating equipment.



Figure 4-1. Cylinder on Rotation Tool

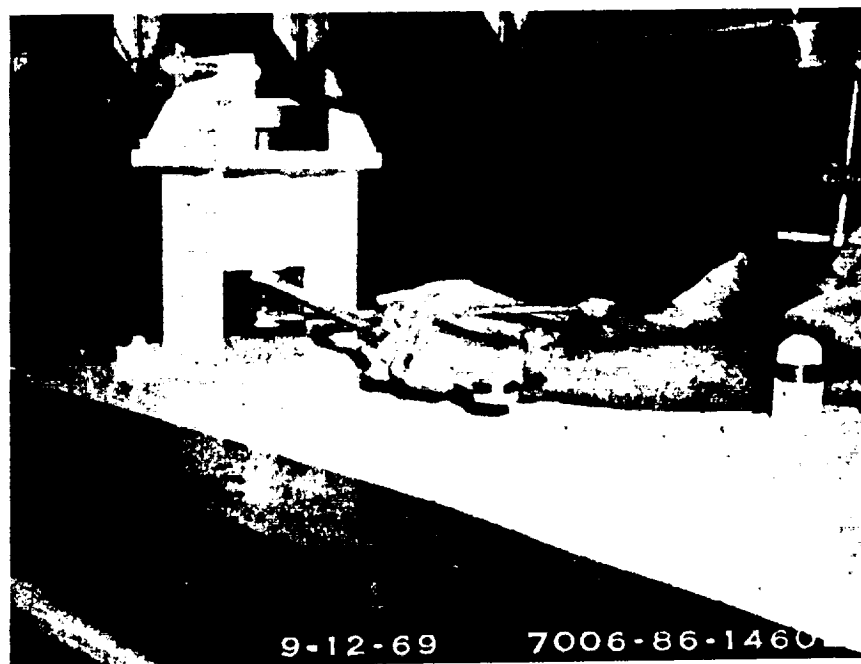


Figure 4-2. Cylinder Positioned on Pads

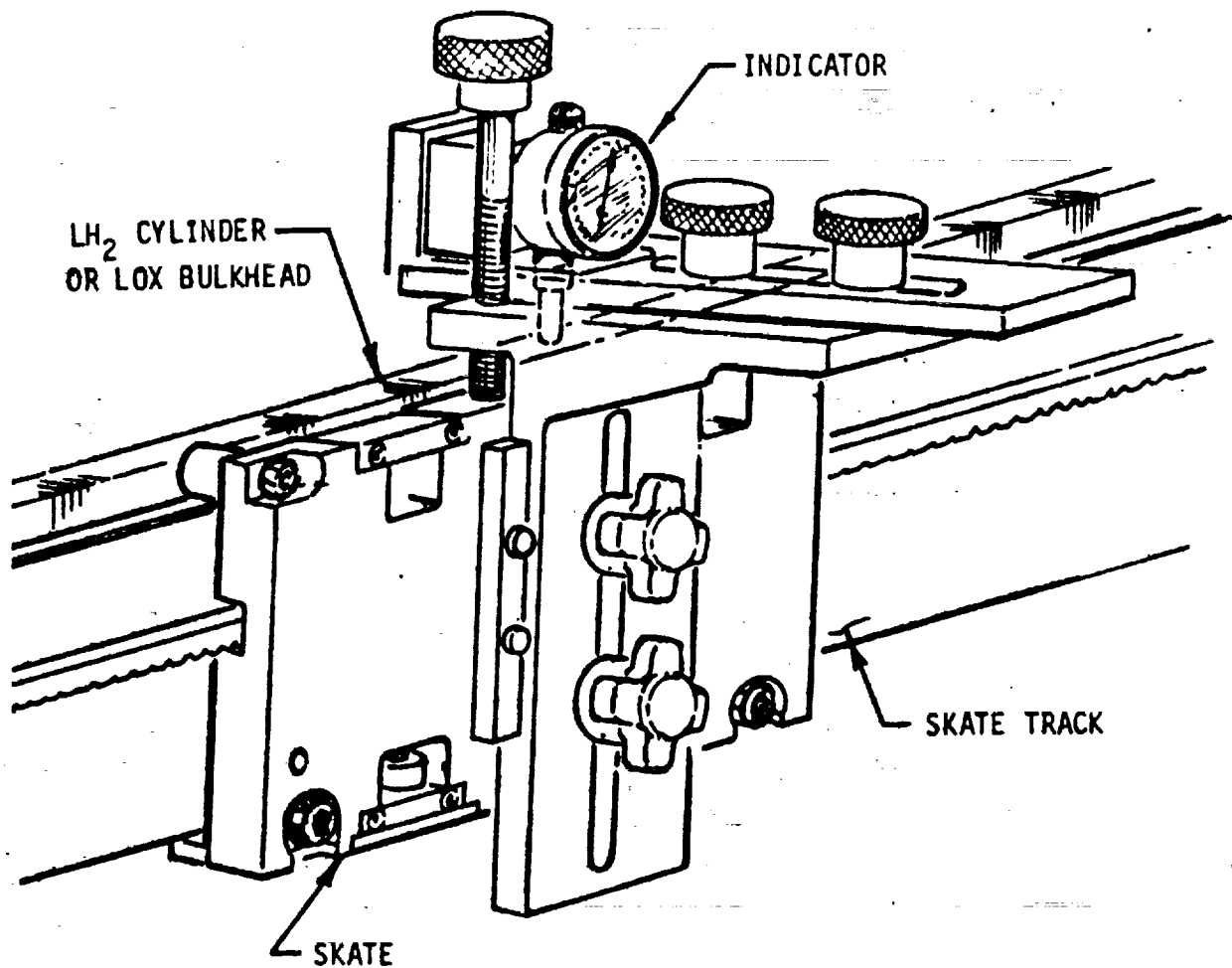


Figure 4-3. Leveling Tool and Dial Indicator



4.3.2 The rotational control box is connected to the power panel on the first floor. The control box safety key must not be left in the control box. The speed of the turntable is set at 20 inches per minute travel by means of the control on the control box.

4.3.3 The key is inserted in the control box and the turntable is rotated while the dial indicator on the level tool is monitored by a mechanic. The cylinder must be level within ± 0.030 inch (total indicator deflection is 0.060 inch). Inspection verifies the reading and clears the FAIR book sequence.

CAUTION

Personnel must keep clear of the rotation assembly.

4.3.4 If the cylinder is not level, the jack screws at each support post are adjusted, using as a base the high point of the cylinder as shown by the dial indicator (Figure 4-2). The remaining points are raised to bring the cylinder within tolerance. The lock nuts on the jack screws are tightened and the level of the cylinder is verified to be within ± 0.030 inch. Inspection verifies the reading and clears the FAIR book sequence.

4.4 POSITIONING CYLINDER 4 ONTO CYLINDER 3

4.4.1 The mechanics position the support saddles (T-7203768) at 12 equally spaced points around the top edge of Cylinder 3. The saddles are checked for clearance before installation to be sure they do not scratch or mar the cylinder (Figure 4-4).

4.4.2 The Cylinder 4-Cylinder 5 assembly is loaded on top of Cylinder 3. This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has the responsibility to assure adherence to accepted safety practices. The move conductor must be in attendance during all phases of the move.

4.4.3 The Cylinder 4 assembly is loaded into the saddles on Cylinder 3. Manufacturing personnel are positioned at six equally spaced areas to guide the bottom edge of Cylinder 4 into the saddles. The cylinders and handling



fixture must be balanced to maintain a level plane within 1 inch during the loading operations (Figure 4-5).

CAUTION

Do not allow the edge of the cylinder to bump the saddles or any equipment such as the skate tracks.

4.4.4 As the cylinder is being lowered, the rotational alignment of the two cylinders is held by aligning Position I of Cylinder 3 to Position I of Cylinder 4. The rotation need only be held within 1/2 inch at this time.

4.4.5 The Material Handling inspector and the move conductor clear the FAIR book sequences for the loading operation at this time.

4.5 PREPARING STATION FOR WELD OPERATIONS

4.5.1 The overhead crane and the spreader bar are left in the station and are used to raise the cylinders during a subsequent operation. The curtain is raised by means of a winch located on the first floor outside the station. After the curtain is secured the temperature and humidity in the station are checked. The temperature should be a minimum of 76 F and the humidity a maximum of 50 percent. If the temperature or humidity exceed the allowable tolerances, Maintenance is called to correct the condition.

4.5.2 The first and second floor of the station must be wet-mopped and the bench tops, bin tops, and exposed beams dusted. The operation of the shoe brush in the station airlock must be checked. The intercom phones inboard and outboard of the cylinders are hooked up and checked for operation.

4.6 PREPARING CYLINDERS AND TOOLING FOR WELD

4.6.1 Cheesecloth dampened with acetone is used to wipe the dust from the vacuum pads of the circumferential sizing tool (T-7204223-401) and supports (Figure 4-5).

CAUTION

Acetone is highly flammable. Approved containers and plastic bottles only must be used. Do not use acetone in open containers.

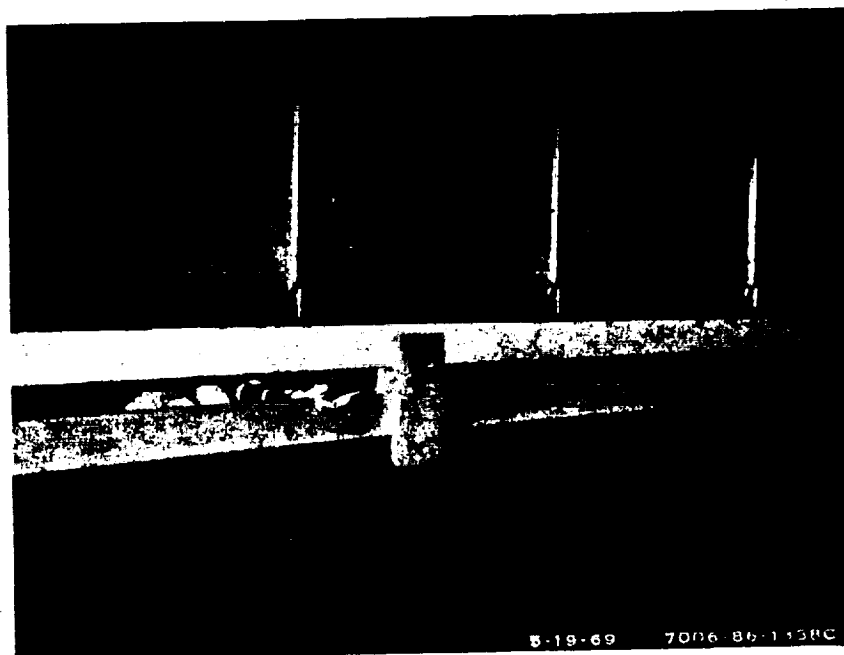


Figure 4-4. Cylinder Support Saddles

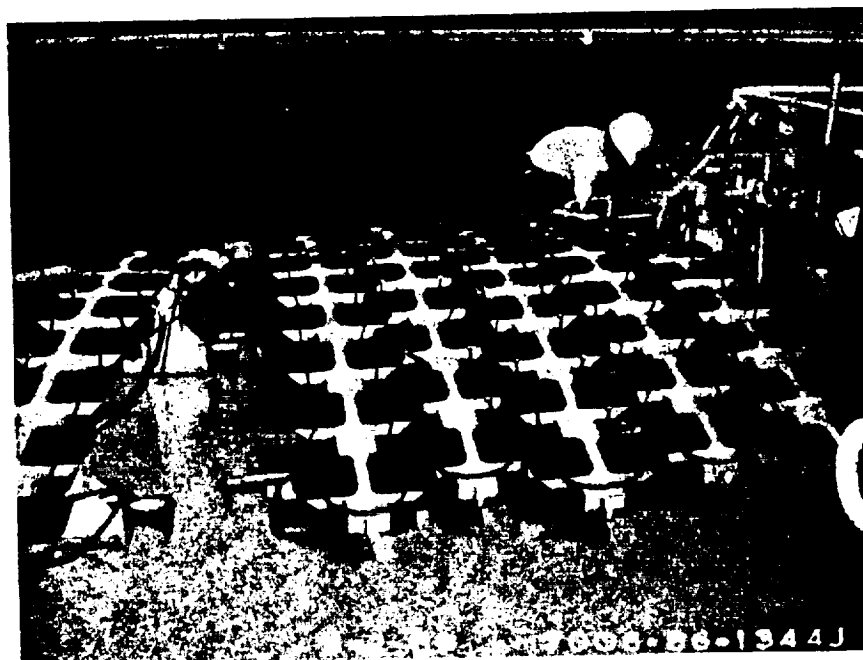


Figure 4-5. Vacuum Chuck Cleaning



4.6.2 The vacuum manifold for the lower support chucks is positioned on the floor on the inboard side of the cylinder and connected to the pigtail leads on the rotating boom (Figure 4-6).

4.6.3 The chip catchers are positioned on the outboard side of Cylinder 3 approximately 6 inches below the butt edge. An Aeroquip band is positioned around the cylinder and the upper flange of each section of the chip catcher is slipped under the band. When all sections are installed around the cylinder, another Aeroquip band is installed around the lower flange. Both bands are tightened by means of the built-in ratchet (Figure 4-7). Sheet metal chip catchers are positioned on the web on the top frame of Cylinder 3 on the inboard side.

4.6.4 One set of lower vacuum chucks is located against the Cylinder 3 wall. The top edge of the chucks is held 1/2 inch below the upper circumferential frame of the cylinder. The first chucks on the outboard ends of the tool must be centered between the first and second vertical grid from the vertical weld on Cylinder 3 (Figure 4-8). Three men are required to position the chucks (Figure 4-9). As the chucks are aligned to the cylinder, the vacuum line from the chucks is connected to the vacuum manifold and a vacuum drawn to secure the chuck. The chucks are tapped lightly to help seat them and prevent vacuum leaks (Figure 4-10). The 8 chucks are aligned around the cylinder and checked for vacuum leaks.

4.6.5 The 8 spreader links are installed between the vacuum chucks and tied in with ball lock pins in each end (Figure 4-11). The links are expanded by hand to form a full circle of the vacuum chucks which help support them in case of vacuum failure.

4.6.6 Eight safety poles are installed between the center of the vacuum chuck frames and the base of the turntable. The saddle end of the pole is positioned on the vacuum chuck frame (Figure 4-12). The pole height is adjusted by loosening and retightening the slip joint at the approximate center of the support pole. The poles must fit snugly between the vacuum chucks and the rotation tool base.

4.6.7 The upper vacuum chucks are installed on Cylinder 4 directly above the lower chucks. The lower edge of the chucks must be held approximately 8 inches above and parallel to the weld land. As the chucks are aligned to the cylinder, the vacuum line from the chucks is connected to the vacuum tap on the lower chuck (Figure 4-13). After applying vacuum, the chucks are tapped lightly to seat them and to prevent vacuum leaks.

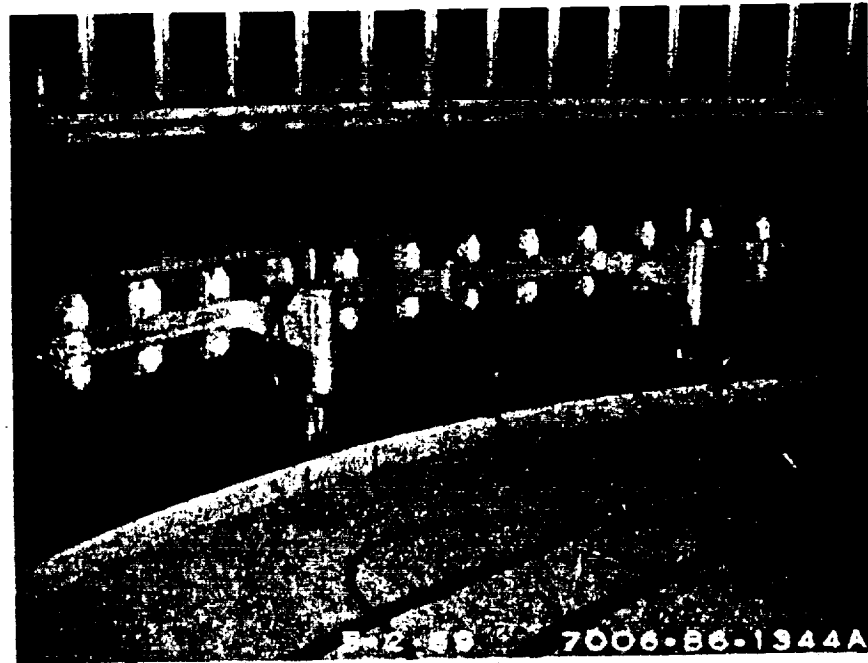


Figure 4-6. Vacuum Manifold

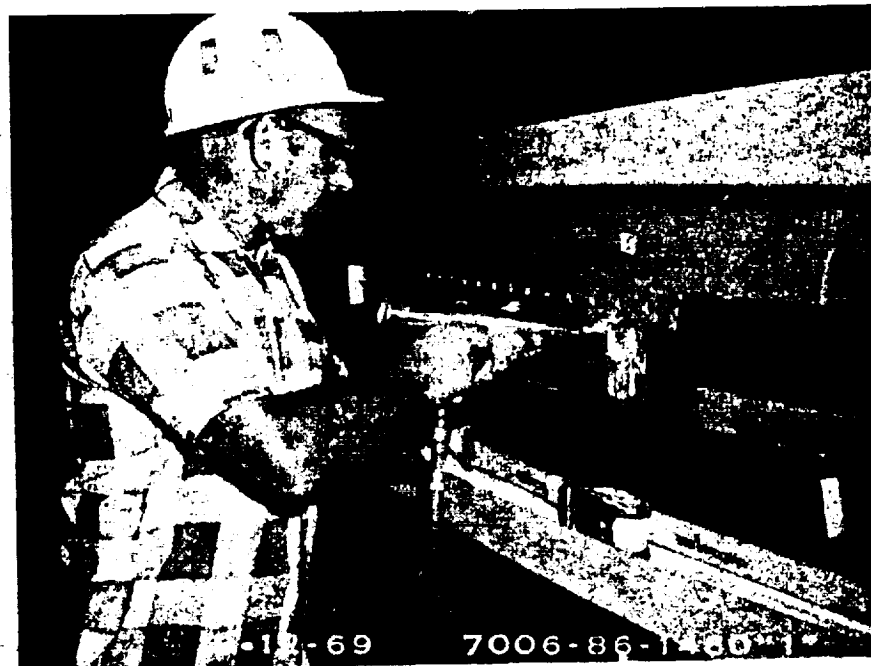


Figure 4-7. Chip Catcher Installation Outboard



Figure 4-8. Lower Vacuum Chucks



Figure 4-9. Installing Lower Vacuum Chucks



Figure 4-10. Attachment of Vacuum Hose to Manifold

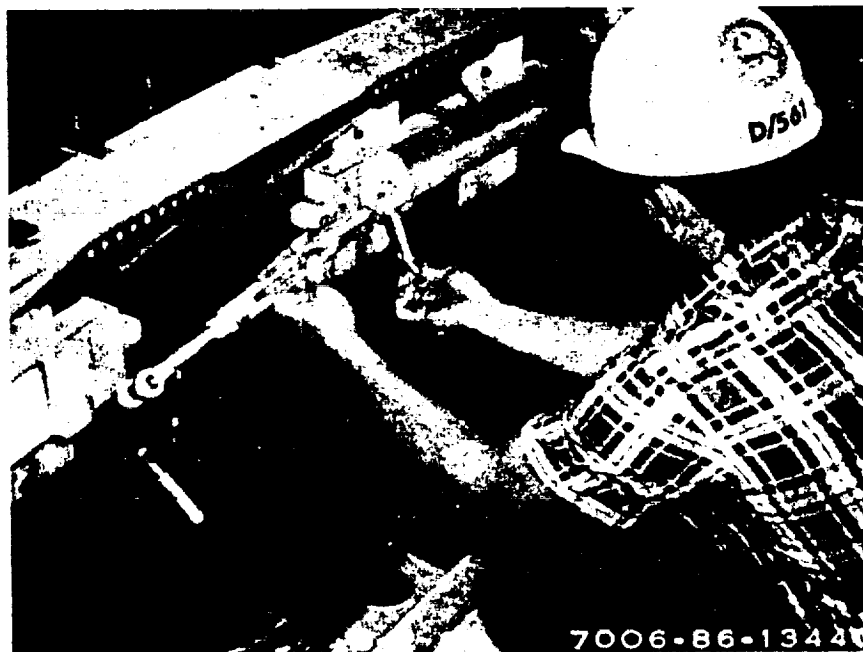


Figure 4-11. Spreader Link Installation



Figure 4-13. Upper Vacuum Chuck Installation

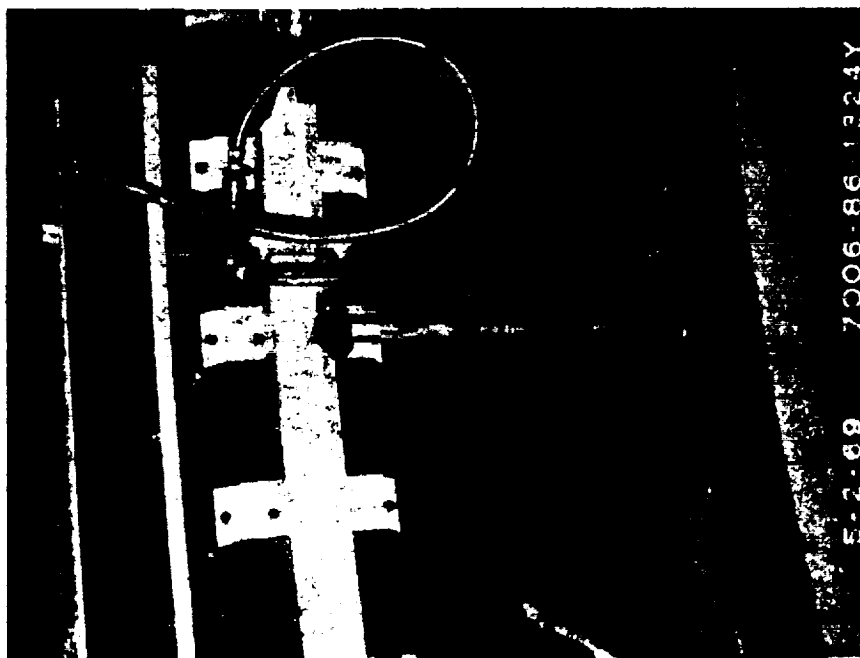


Figure 4-12. Safety Pole Installation

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4.6.8 The spreader jacks are installed between the ends of the vacuum chucks and tied in with ball lock pins in each end (Figure 4-14). This forms a full circle of the vacuum checks and helps to support them in case of a vacuum failure. The vacuum manifold and hydraulic lines for the jack system are positioned onto the lower vacuum chuck supports around the cylinder (Figure 4-13).

4.6.9 The 16 control arms (A) are installed into the lower support chuck bearings (B) as shown in Figure 4-15. The horizontal arm (C) on top of the control arm is adjusted inboard or outboard by means of the adjusting screw (D) until the pin (D) can be installed through the upper vacuum support channel. The bolt (F) is loosened if required to allow the control arm to be raised or lowered.

4.6.10 The lines from the hydraulic cylinder (G) are connected to the manifold, which in turn is connected to the rotating boom. With the clamp (F) still loose, extend the hydraulic cylinder (G) 12 inches. This setting is used with the cylinder resting in the support saddles. Tighten the clamp (F) onto control arm (A) with the cylinder extended.

4.6.11 The spanner nut (H) is rotated until 1 inch of the thread shows between the spanner nut and the support plate (I). The clamp (J) is loosened and lowered until it rests on the support plate (I). The clamp (J) is

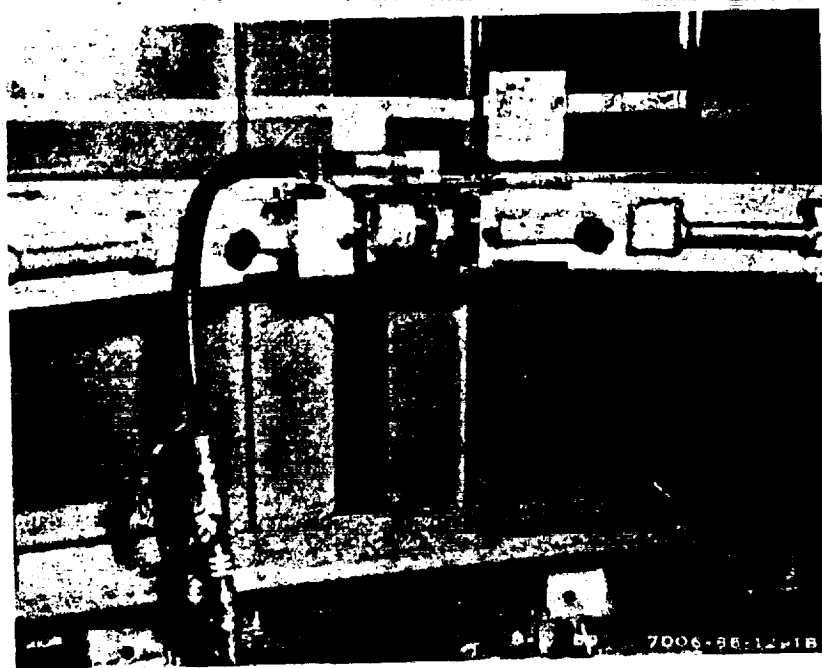


Figure 4-14. Spreader Jack Installation

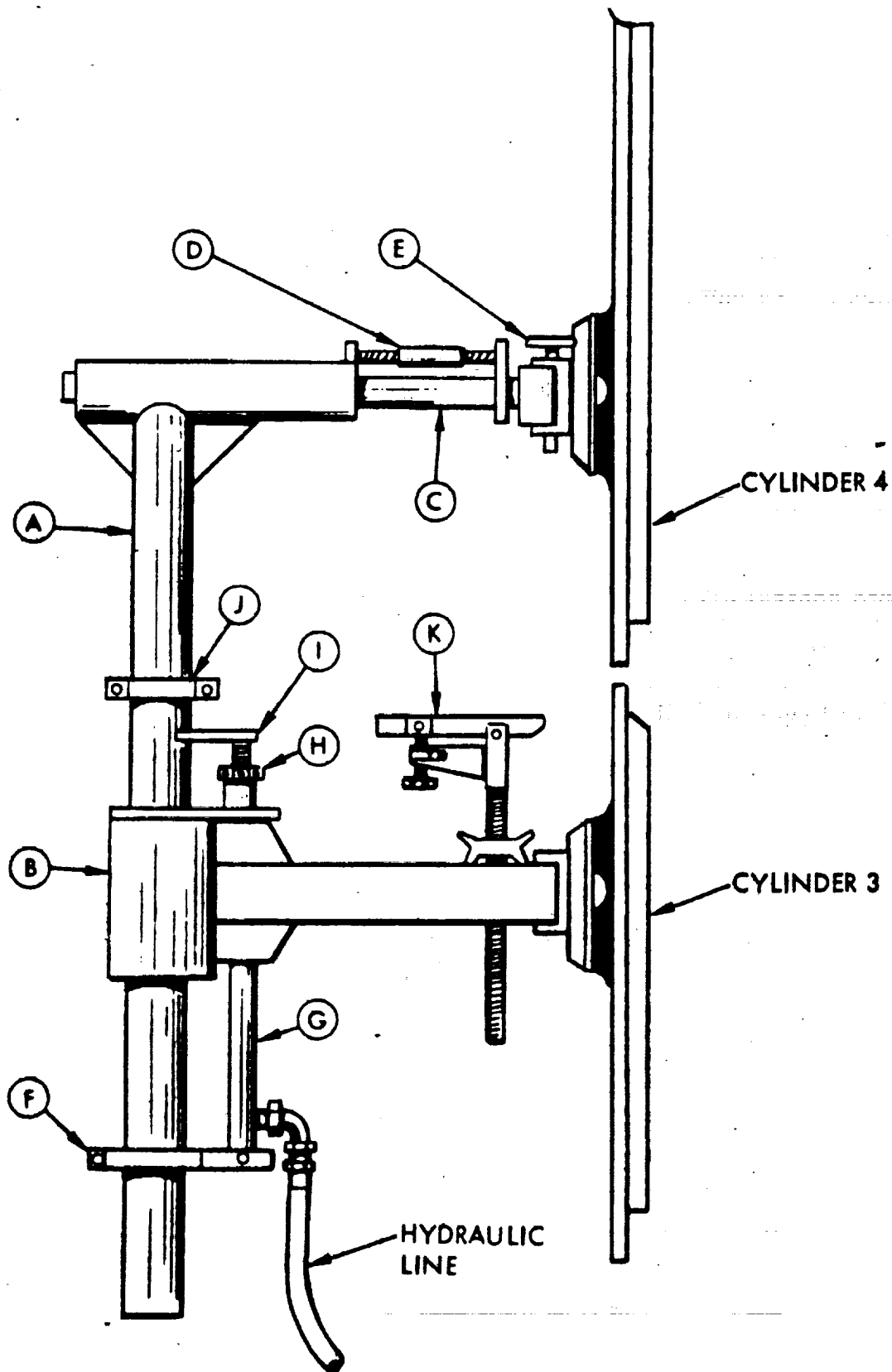


Figure 4-15. Vacuum Chucks

then tightened. The 16 support posts are set using this procedure. The tooling and the Cylinder 4 assembly are checked for clearance before raising the assembly.

4.6.12 The hydraulic reservoir is connected to the plant air supply. The sequence procedure posted on the hydraulic supply pump is followed to raise the Cylinder 4 assembly until a 6-inch gap exists between the butt faces of Cylinders 3 and 4 (Figures 4-16 and 4-17). The overhead bridge crane is used to supplement the system. Four safety blocks are clamped between the cylinders at the four vertical welds (Figure 4-17).

CAUTION

The C clamps must be protected with Teflon or aluminum foil to prevent damage to the weld land. The spacer blocks must be washed with acetone before installation.

4.6.13 A strip tape numbered in 3-inch increments is applied to the out-board side (Figure 4-18). When applying the strip, the zero mark is located

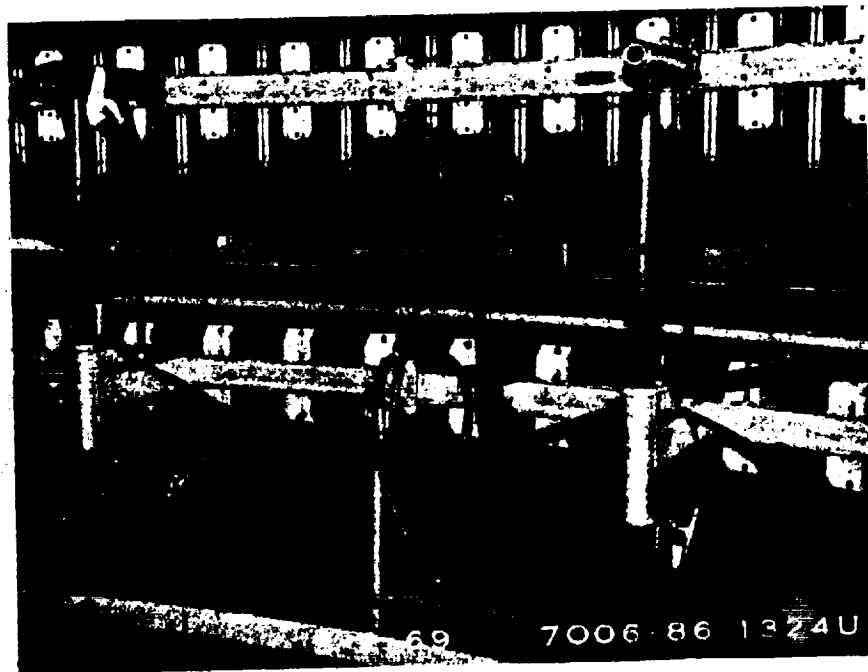


Figure 4-16. Cylinder Raised to 6-Inch Gap



Figure 4-17. Safety Block Installation

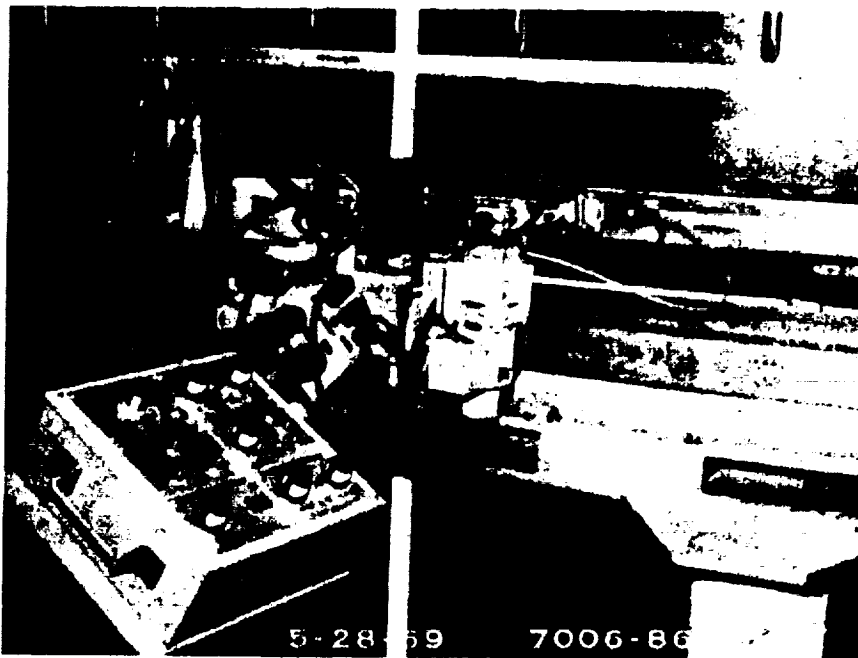


Figure 4-18. Installation of Tape (3-Inch Marked) Outboard



at the Position I mark on Cylinder 3. The tape is applied approximately 4 inches below the top edge of Cylinder 3.

CAUTION

Use only approved tapes to position the numbered tape.

4.6.14 A Mylar tape is applied on the inboard side of Cylinder 4 approximately 4 inches above the lower edge of the cylinder. The tape is applied between the vertical stringers around the entire circumference. The tape also is marked in 3-inch increments, starting with zero at Position I. The marks on this tape must coordinate with the tape on the outboard side of Cylinder 3 (Figures 4-5 and 4-19).

4.6.15 Stringer end protectors are installed on the ends of the vertical splices of both cylinders (Figure 4-20).

4.6.16 Inspection measures the weld land thickness of both cylinders and logs the dimensions on the ITI SB-121 form in the FAIR book. The measurements are taken in 3-inch increments. In case of out-of-tolerance readings, undersize areas must be submitted to Material Review and oversize areas must be draw-filed to tolerance.

4.6.17 Inspection logs the pi-tape readings in the FAIR book. These readings were taken in the bulkhead fabrication building when the cylinders were trimmed. Any out-of-tolerance dimensions are submitted to Material Review.

4.7 VERIFICATION PANELS

4.7.1 These panels are run prior to preweld cleaning as described in Section 1.14.

4.8 PRECLEANING

4.8.1 Preweld cleaning operations are performed as described in Section 1.12.

CAUTION

Only personnel qualified for preweld cleaning are to clean the weld joint area.

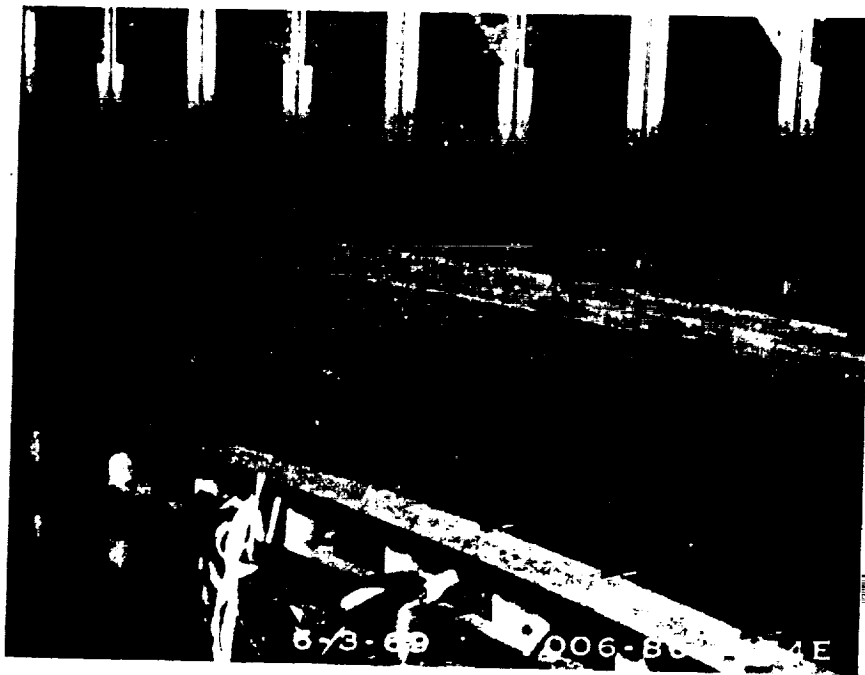


Figure 4-19. Marked Tape Installed Inboard

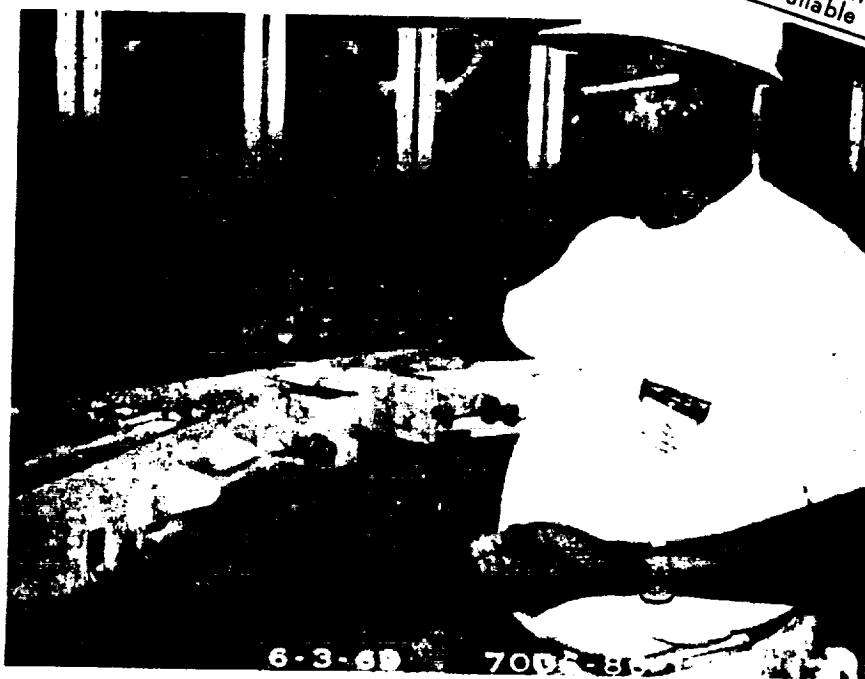


Figure 4-20. Installation of Stringer End Protectors



4.9 WELD TOOLING SETUP

4.9.1 During precleaning operations, the 8 circumferential sizing tools are washed using acetone-dampened cheesecloth. The circumferential sizing tools are checked for nicks and burrs on the fingers which come into contact with the weld lands. The defects are draw-filed with a mill file and washed with acetone-dampened cheesecloth. The tools are wrapped in aluminum foil.

4.9.2 The 16 T-supports (K) are installed into the lower supports (B) as shown in Figure 4-21. The height is adjusted using the wing nut (L). The top of the crossbar is set 2 inches below the top edge of Cylinder 3.

4.9.3 The center T-supports are located on the lower support channel by hooking them over the top flange of the channel. The set screw is then adjusted to level the top of the support. The height is adjusted with the wing nut. The top of the crossbar is set 2 inches below the top edge of Cylinder 3. One of the supports is located in the center of each of the bottom vacuum chucks (Figure 4-22). After the precleaning operation is completed, all chips are vacuumed from the area.

4.9.4 The circumferential sizing tools (T-7204223) are installed using the hydrolift hoist. An adapter (T-7204223-903) ties into the circumferential sizing tool by means of three pins. Two of the pins tie into the back flange of the tool and one through the center web. The adapter (detail -903) is then tied to the hook of the hydrolift hoist located on the second-floor level on the inboard side of the cylinders. The turntable is rotated so that the first circumferential sizing tool can be located on the T-supports of the lower vacuum chucks (Figure 4-23).

CAUTION

The turntable and all hoses and cables must be checked for clearance before rotating the turntable.

4.9.5 The first circumferential sizing tool is hoisted with the hydrolift, and the arm is moved to position the circumferential sizing tool on the T-supports. The tool is centered on the lower vacuum chucks (Figure 4-24). The turntable is rotated and the remaining 7 circumferential sizing tools are hoisted into position.

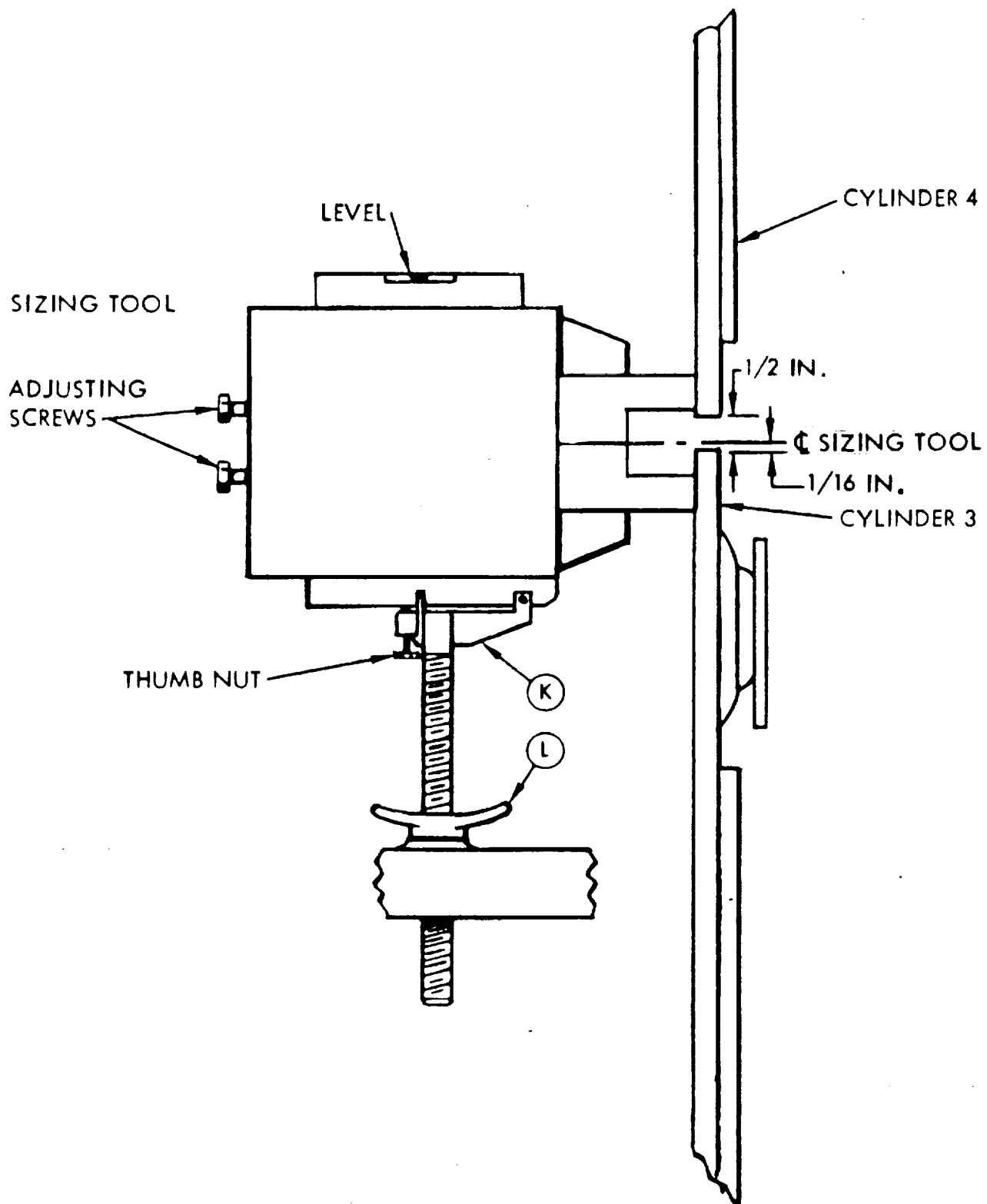


Figure 4-21. Height Adjustment



Figure 4-22. Center Supports for Sizing Tool

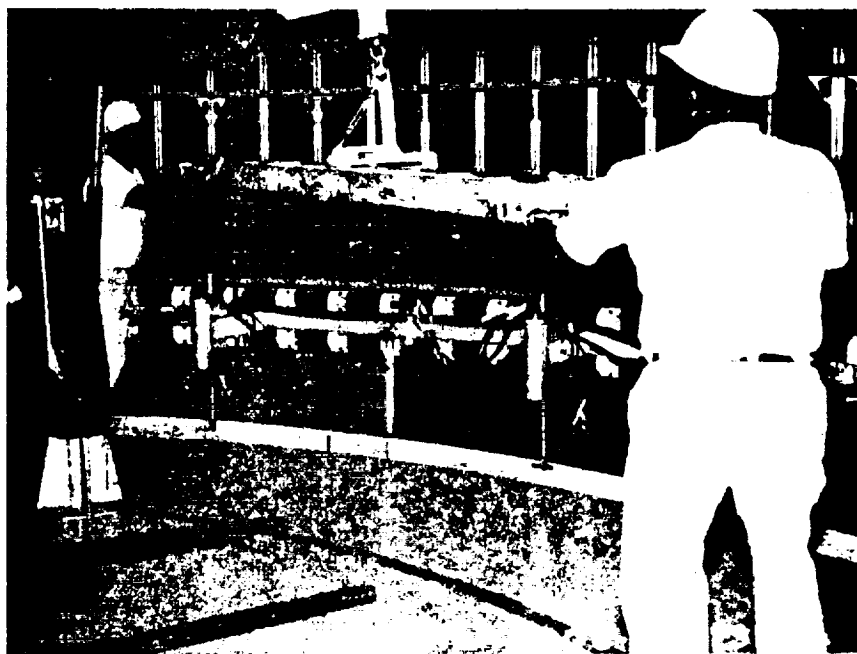


Figure 4-23. Sizing Tool Hoisted Into Position

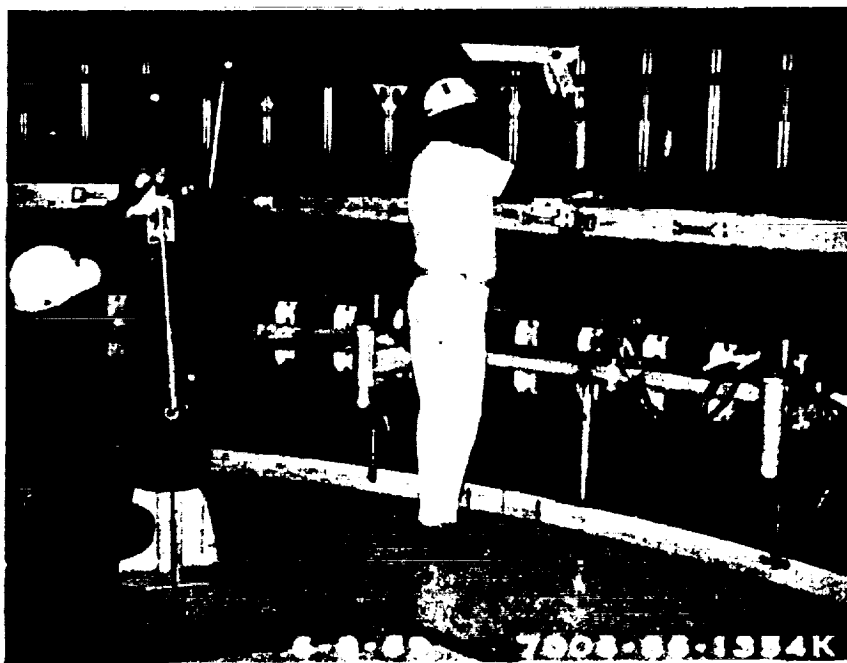


Figure 4-24. Installation of Sizing Tool

4.9.6 The spreader jacks (T-7204223-381) are installed between the circumferential sizing tools at 8 places. The spreaders are attached by means of 1/2-inch ball lock pins through slotted holes. It may be necessary to pry the last tools apart to install the last spreader jack. A turnbuckle placed between the ends of the circumferential sizing tools and then expanded forces the tools apart far enough to install the spreader jack. Do not allow the tools to contact the cleaned butt edges of the cylinder (Figure 4-14).

4.9.7 The dust caps are removed from the ends of the hydraulic lines attached to the spreader jacks, and the lines are connected to the hydraulic manifold. The valves are opened after hooking the lines into the system. If the spreader jacks have not previously been wrapped in plastic, it is wrapped around them to prevent hydraulic oil from contaminating the cleaned weld surface in case of hydraulic oil leaks.

4.9.8 The top edge of Cylinder 3 must be within 1/16 inch below the centerline of the circumferential sizing tools. The height of the circumferential sizing tools is adjusted by means of the adjusting wing nut (L). A spirit level is laid on top of the circumferential sizing tools and they are leveled by means of the thumb nut on the support (K) (Figure 4-21).

CAUTION

Do not touch the cleaned surfaces of the cylinders while adjusting the circumferential sizing tools.

4.9.9 By means of the hydraulic jacks (G) in Figure 4-15, the Cylinder 4-Cylinder 5 assembly is lowered over the circumferential sizing tools until a 7/16- to 1/2-inch gap exists between the cylinder butt faces. The clamp (J) rests on I at the 16 locations around the circumference (Figure 4-15). As the assembly is lowered, the overhead bridge crane operator must slack off slightly on the hydraulic system.

CAUTION

Follow the instructions posted on the hydraulic console for lowering the Cylinder 4-Cylinder 5 assembly. Only qualified personnel are to operate the pump. Use extreme care in lowering and continually check around the circumference so that the butt face of Cylinder 4 does not contact the circumferential sizing tool fingers. The lowering operation must be coordinated with the move conductor and the riggers.

4.9.10 The hydraulic system is pressurized to 3000 psig to expand the circumferential sizing tools.

CAUTION

Follow the instructions posted on the hydraulic pump.

4.9.11 This operation should occur near a shift change. The joint is covered with aluminum foil on the inboard and outboard sides using only approved tape.

CAUTION

Do not touch the cleaned weld joint.

4.10 FINAL CLEANING OPERATIONS

4.10.1 The aluminum foil is removed from the weld joint and the joint is prepared as defined in Section 1.12.

4.11 FINAL WELDING PREPARATION

4.11.1 After completion of the final cleaning operation, the rotational alignment tool (T-7203718) is installed. The tool attaches to two of the tunnel attachment holes (left-hand) in Cylinder 3 and two of the holes (left-hand) in Cylinder 4. The tool is provided with 1/4-inch inside diameter and 3/4-inch outside diameter bushings and special 1/4-28 screws. The bushings and screws are slipped through the holes in the alignment tool. One hole in each half of the tool is slotted vertically to allow for tolerance in the tunnel attachment holes (Figure 4-25).

4.11.2 The circumferential sizing tool pressure is lowered to 500 psig and precleaned 0.040-inch stainless steel shims are installed at 12 equally spaced points around the circumference of Cylinder 3. The spacers are taped to Cylinder 3 below the cleaned area with Mylar tape. One leg of the shim, approximately 1/2- to 3/4-inch long, must rest on Cylinder 3 butt edge. These shims are used to prevent Cylinder 4 from bearing on Cylinder 3 during the lowering and rotational alignment operations.



Figure 4-25. Rotational Alignment Tool Installation



CAUTION

The shims must be precleaned with acetone prior to installation and must not be contaminated during installation. Only approved tape is used on the cylinder surface.

4.11.3 The Cylinder 4-Cylinder 5 assembly is lowered by the use of a spanner wrench on the nuts (H) shown in Figure 4-15. The cylinder is progressively lowered by turning the nuts counterclockwise on the 16 support jacks (G). The lowering operation is monitored from the outboard side of the cylinders. Rotational alignment of the cylinders is checked during lowering.

4.11.4 The Cylinder 4-Cylinder 5 assembly is lowered to leave approximately a 1/8-inch gap around the circumference. The rotational alignment is checked by means of the pointer on the upper alignment tool against the scale on the lower tool. Tolerance must be kept within 0.030 inch. The circumferential sizing tool pressure may have to be lowered to zero and the cylinder assembly rotated by personnel pushing from inside the cylinder. In extreme cases, a cable hookup and turnbuckle is used for rotation as shown in Figure 4-26.

4.11.5 The circumferential sizing tools are repressurized to 500 psi if the pressure has been lowered for rotation. Cylinder 4 is lowered at Position I to leave approximately a 0.040-inch gap. Rotational alignment is checked and the circumferential sizing tools pressurized to 600 psig (Figure 4-25).

CAUTION

Only qualified personnel may operate the hydraulic pump. Rotational alignment is verified by Quality Control and NASA inspection and the item is cleared in the FAIR book.

4.11.6 Approval to weld is verified in the FAIR book.

4.11.7 During the final cleaning operation the welders and the weld engineers verify the equipment. The gas is checked for moisture content, the wire is checked, and the heat treat number, size, etc., logged in the FAIR book. A bead-on verification plate is run by the welder and checked by Quality Control along with the machine settings. The weld heads are moved to the skate track at each weld position. The welder connects the sensing and ground leads to the assembly and the connections are checked by the weld engineers.

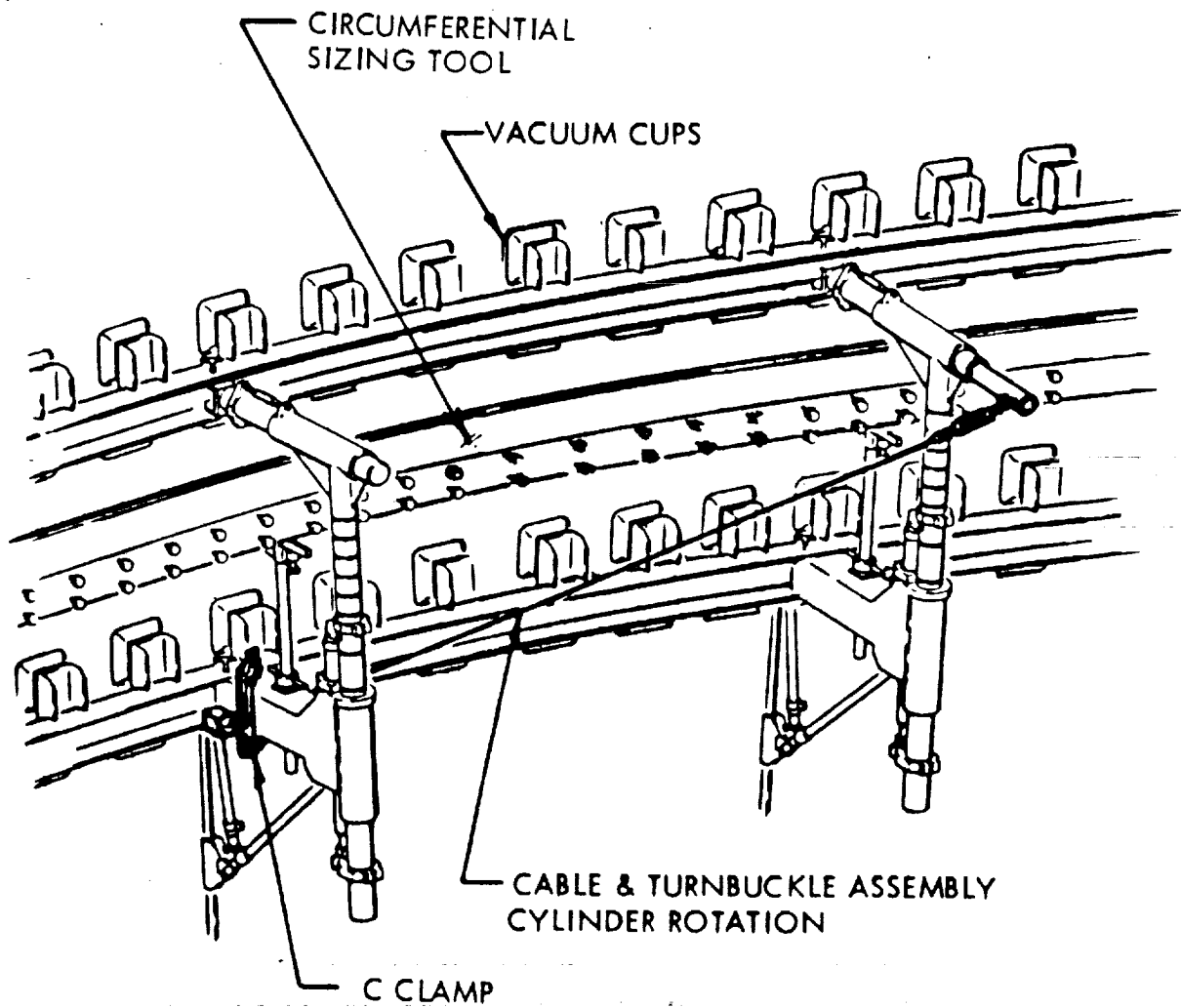


Figure 4-26. Use of Cable for Rotation



4.12 WELDING OPERATIONS

4.12.1 Two tack-weld teams perform the circumferential welds. Each consists of a welder, an offset manipulator, and a vacuum hose operator working outside the cylinder, and another offset manipulator on the inside. The teams operate 180 degrees apart. Two other men, one on the outboard side and one on the inboard side for each weld station, preset the offset ahead of the tacking crew. The weld machine parameters are reprogrammed for intermittent tack, and the tack weld run per the 971-D-00265 Weld Schedule (Figure 4-27).

4.12.2 Communication between the personnel inboard and outboard is by means of intercom headsets. The manipulator checks the offset using a 0.050-inch thick stainless steel gauge and informs the team member on the inboard side which cylinder must be moved to arrive at an offset target of 0.010 inch. The inside manipulator adjusts the offset by means of the bolts on the inboard side of the circumferential sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers (Figure 4-28).

4.12.3 The first tack is located at approximately Position I, where a 0.040-inch gap exists. The offset is set by the manipulating team. The joint area is vacuumed to remove any foreign material from the faces of the cylinders, being careful not to touch the surfaces. The weld head is moved into position for the first tack and locked to the gear rack on the track. The torch is positioned for the tack, the circumferential sizing tool pressure of 6000 psi is verified, and the first tack is made. A 3-inch long tack is run per the 971-D-00265 Weld Schedule and the machine tapered out. A space of 6 inches is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for four or five tacks. The rotational alignment tools and the 0.040-inch stainless steel shims are removed.

4.12.4 The gap around the cylinders is checked, and if the gap 180 degrees from the first tack exceeds 0.040 inch, the circumferential sizing tool pressure is lowered to 500 psi and Cylinder 4 is lowered to leave a 0.040-inch gap. If required, the cylinders can be pulled together by means of a large clamping tool (Figure 4-29). The circumferential sizing tool is repressurized to 6000 psi.

4.12.5 When the gap is determined to be 0.040 inch at Position III (180 degrees from the first tacks), the tacking operation begins at the second weld position. The same offset alignment procedure is used. The cylinders at the two weld stations are progressively tack-welded with 3-inch long tacks at 9-inch centers. When each weld machine has tacked the



Figure 4-27. Offset Adjustment

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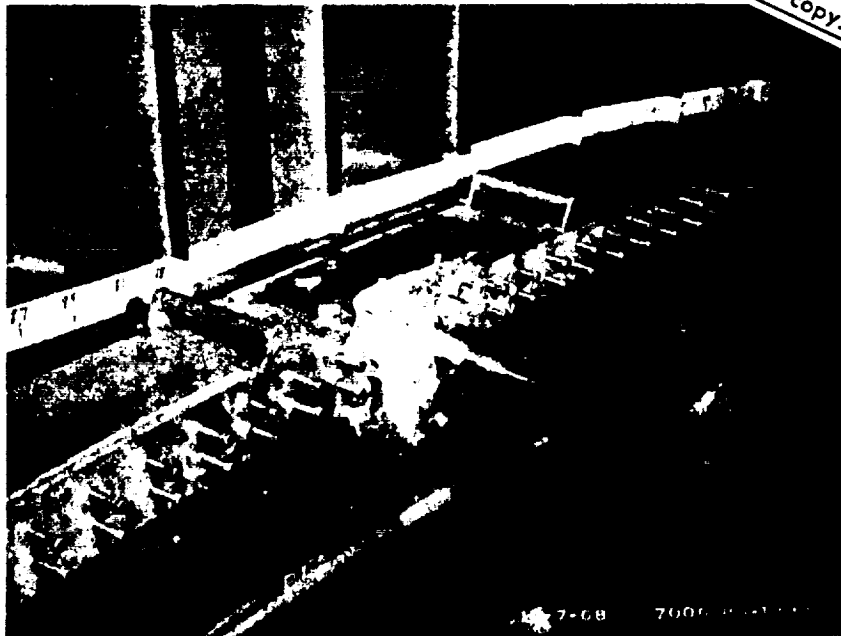


Figure 4-28. Offset Adjusting Screws

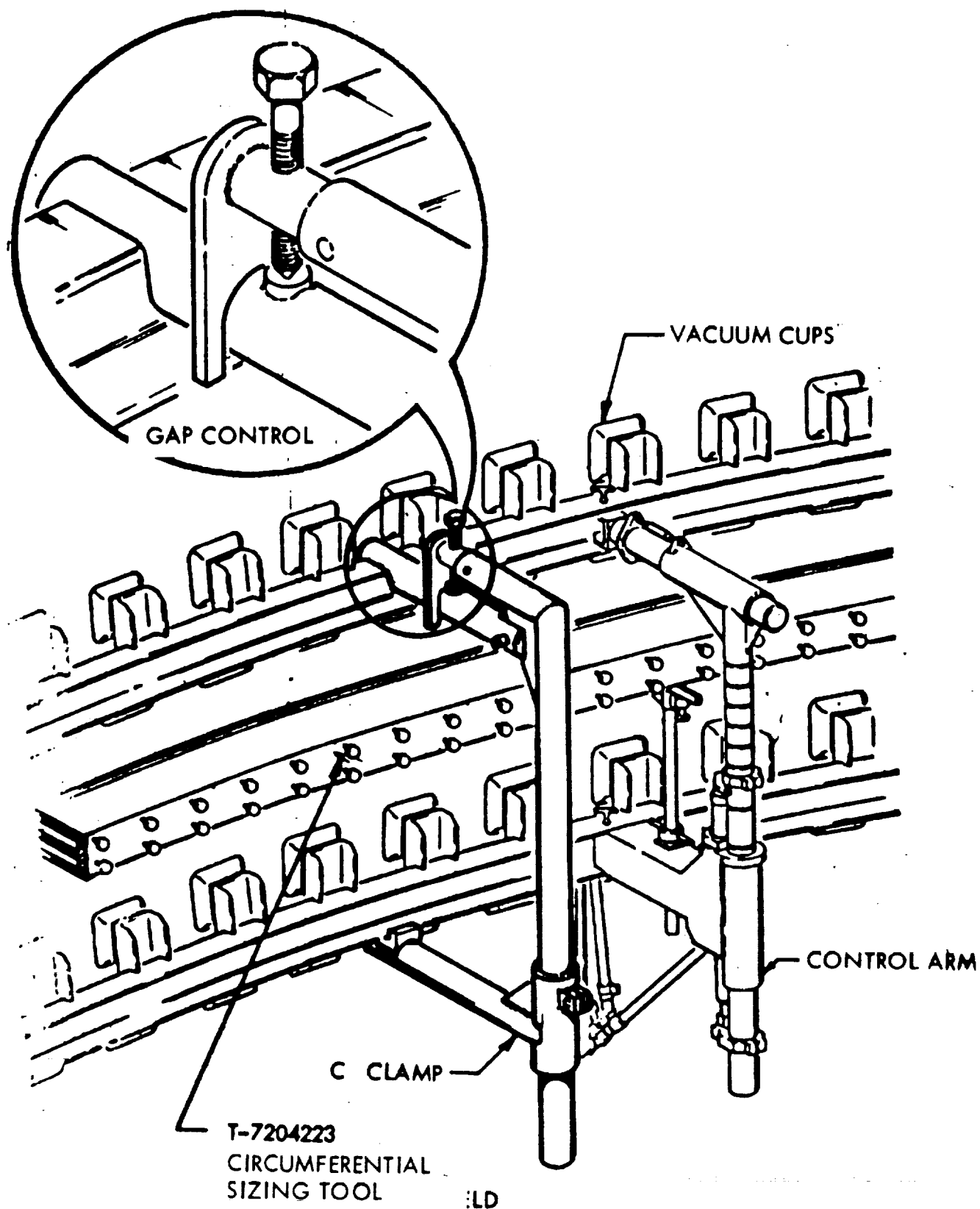


Figure 4-29. C Clamp for Drawing Cylinders Together



cylinders the full length of the skate track, approximately 8 feet, the turntable is rotated to a new tack position. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.015-inch offset after welding is checked by supervision and reworked if required.

4.12.6 The circumferential sizing tools are checked for centering. The pressure is dropped if the tools must be recentered. After recentering, they are repressurized to 6000 psig. All the adjusting screws must be backed off and then readjusted finger-tight to assure contact of the circumferential sizing tools with the cylinders.

CAUTION

Screws must not be over-tightened.

4.12.7 The weld machine parameters are programmed for the continuous tack pass per the 971-D-00265 Weld Schedule. The turntable speed is set on the turntable control box and the direction of travel checked. The turntable travels in a clockwise direction. An air motor with a 1/4-inch ball rotary file is set up at each weld station to grind out the minute crater cracks left when the weld machine sequences out after running the continuous tack pass.

4.12.8 The weld heads are positioned at the right-hand end of the skate tracks, leaving sufficient skate travel for the weld heads to sequence out in the event the turntable malfunctions. Weld heads are locked into the track and the travel potentiometer set for the correct skate speed. Should the turntable stop, the welder immediately switches on the skate travel switch and the weld heads sequence out. A final check is made on turntable speed, direction of travel, weld machine programming, skate-to-track lock, and circumferential sizing tool pressure. A countdown is called out on the intercom and at the words "sequence start", both welders energize their weld machines. As soon as both arcs stabilize, the turntable is started. In the event one machine fails to start, two courses are open to the supervisor or weld engineers: the operating machine can continue while the second machine is checked out for the cause of the misfire and fired in a running start, or the operating weld head is sequenced out until the second machine is checked and both machines are restarted.

4.12.9 The continuous tack pass is performed per the 971-D00265 Weld Schedule. Each machine overlaps the start of the other machine for a minimum distance of 6 inches or until a good tie-in is made. As each machine sequences out for any reason, the tailout crater is ground out to a depth of



approximately 0.060 inch with the ball rotary file. The turntable is not shut off until both machines have sequenced out. The crater is ground out as soon as the welding arc is terminated so that any small cracks do not propagate.

4.12.10 As the cover tack pass cools down, the circumferential sizing tools are again checked for centering and adjusted as required. If the tools are moved, they are repressurized to 6000 psi.

4.12.11 The entire cover tack weld bead is brushed using a fine stainless steel rotary brush in an air motor. The brush is moved in long strokes in one direction only. Dust and soot are vacuumed from the area. The surface must not be touched with any material except the wire brush.

4.12.12 The weld machine parameters are programmed for the penetration weld pass per the 971-D-00265 Weld Schedule. The current override control is moved to the inside of the cylinder and the control switch of the weld pack turned on as shown in Figure 4-30. The intercom between inboard and outboard at each weld station is checked for operation and availability of the air motors and 1/4-inch ball rotary files is verified. The turntable speed is set for the penetration pass on the control box and rechecked for direction of travel. The turntable travels in a clockwise direction. The position and centering of the circumferential sizing tools are rechecked. Before starting the penetration pass, the operators on the inboard side must be in position and in contact with the welder on the outboard side by means of the intercom.

4.12.13 The countdown is started and at sequence start both machines are energized. When the arcs stabilize, turntable rotation is started. The operator on the inboard side controls the amount of drop-through on the penetration pass and also is responsible for tracking the seam. The drop-through is observed through holes in the circumferential sizing tools (Figure 4-30).

CAUTION

The cables on the inboard side are checked to assure they do not become entangled as the boom rotates.

4.12.14 The penetration pass is run per the 971-D-00265 Weld Schedule. Each machine overlaps the start of the other machine for a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground out to a depth of approximately 0.060 inch and checked to assure that all tailout crater defects are removed.

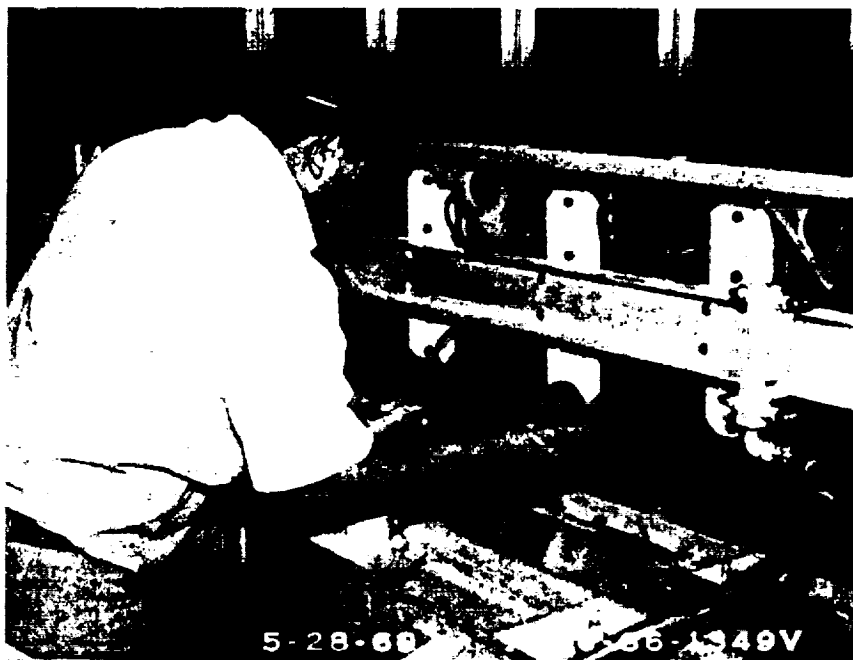


Figure 4-30. Current Override Control

4.12.15 The drop-through is checked for incomplete penetration. If there are any areas of incomplete penetration, the turntable is rotated to bring the area to the closest weld head. The defect can be picked up by either weld machine, using the skate travel of the head instead of the turntable rotation.

4.12.16 After the penetration pass or pickup operations are complete, the circumferential sizing tool pressure is lowered and the 8 spreader jacks are removed and stored neatly on the inboard side of the cylinders. The 8 upper vacuum chucks and the 16 support arms are removed and stored on the first-floor tooling carts.

4.12.17 The stringer end protectors are reinstalled on the ends of the stringers of both cylinders (Figure 4-20). The turntable is checked to assure clearance and rotated to position a circumferential sizing tool at the hydrolift. The hydrolift with the T-7204223-903 adapter is used to remove the first circumferential sizing tool and lower it to the floor. The turntable is rotated progressively to remove the remaining 7 tools.

CAUTION

The lower chucks are not removed at this time.



4.12.18 The drop-through (inboard) side of the weld is inspected for uncercut, incomplete penetration, folds, etc., per the weld specification. The drop-through is checked by the inspector and if necessary a reference squawk is prepared. The weld bead is milled on the inboard side to a height of 0.010 to 0.015 inch, using three or four weld shavers. Care is exercised that the shaver blades do not cut the parent material (Figure 4-31).

4.12.19 The weld bead is smoothed using a Bear-Tex wheel in an air motor. The wheel is moved with long even-pressured strokes, not pausing in any one area, which causes high and low spots. The Bear-Tex wheel is not run crosswise or at an angle to the weld bead (Figure 4-32).

4.12.20 A fine stainless steel rotary brush in an air motor is used to remove any soot from the outboard side of the weld. The outboard side is checked for any folds or minor surface defects, which are blended out with a ball rotary file prior to X ray. Both the inboard and outboard sides are washed using clean cheesecloth and acetone.

4.12.21 The weld is X-rayed and inspection report prepared. Any defects identified are evaluated by the Manufacturing supervisor and weld engineer to determine which should be reworked prior to running the cover pass. A Manufacturing Request for Rework (Form 021S) is filed requesting planning tickets for in-process rework.

4.12.22 Defects are reworked in accordance with procedures in Section 10.

4.12.23 When rework is complete, the circumferential sizing tools are reinstalled following the procedure outlined for the first installation. The system is pressurized to 6000 psig and checked for hydraulic leaks.

4.12.24 The following operations require white garments. The outboard side of the weld is wiped down with acetone and cheesecloth and brushed with a clean fine stainless steel brush in an air motor.

CAUTION

The wire brush is moved in long strokes in one direction only.

4.12.25 The weld machine parameters are programmed for the cover pass per the 971-D-00265 Weld Schedule. The turntable speed is set for the cover pass and the clockwise direction of travel is verified. The override control remains off. Availability of the air motors with 1/4-inch ball rotary files at each weld station is verified. The position and pressure of the circumferential sizing tools are checked.

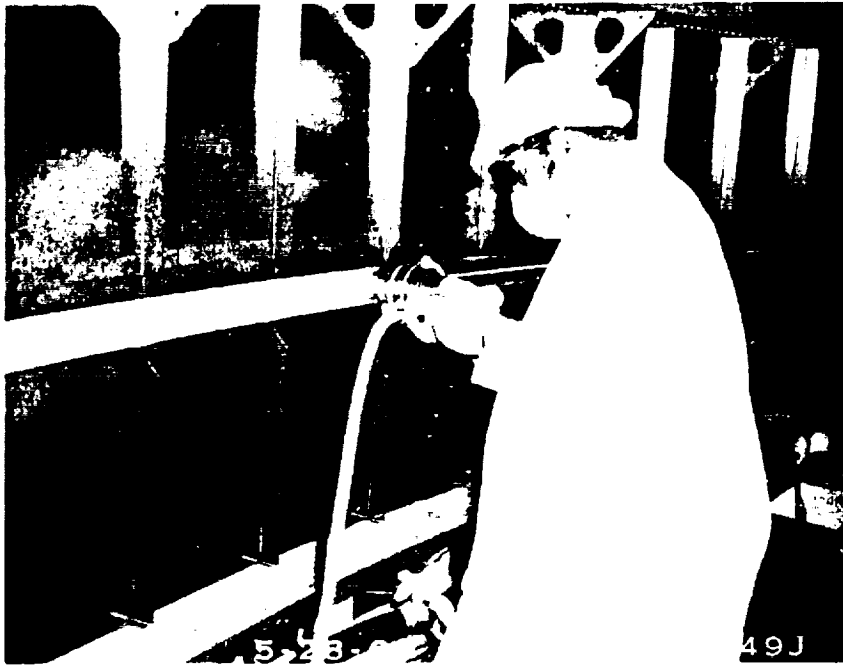


Figure 4-31. Milling Weld Bead



Figure 4-32. Abrading Weld Bead With Bear-Tex Wheel



4.12.26 The countdown is started and at sequence start both machines are energized. When both arcs stabilize, turntable rotation is started and the first cover pass is run. The bottom edge of the penetration pass must be covered by the first cover pass. Cover passes overlap prior welds at least 6 inches before sequencing out.

4.12.27 The sequence-out crater is ground with the rotary file. The weld bead is wire-brushed and inspected for lack of fill areas. Determination is made whether to run a complete second pass or only intermittent pickup passes.

4.12.28 If a second cover pass is determined, it is run using the same operations as for the first cover pass. If intermittent pickups are required, the turntable or the skate track is used depending on the length of the area. After the second cover pass or intermittent pickups are made, the weld is inspected for defects.

4.12.29 The stringer end protectors are reinstalled on the ends of the stringers of both cylinders (Figure 4-19).

4.12.30 The circumferential sizing tools are removed as outlined in Step 4.12.17, and at this time the lower vacuum chucks are removed.

4.12.31 Three or four weld shavers are used to mill the cover passes to a height of 0.010 to 0.015 inch. Care must be exercised so the parent material is not cut. The weld bead is polished with a Bear-Tex wheel, moving in long strokes.

4.13 POST-WELD OPERATIONS

4.13.1 X-ray personnel X-ray the entire weld. The film is read out and triangulation shots made of any questionable areas. Rework, if required, is accomplished by the in-process method outlined in Section 10, or by Material Review action. After X ray is complete, the joint is inspected both inboard and outboard, using the fluorescent dye penetrant method. Manufacturing personnel assist in the fluorescent penetrant inspection by blending out defects which do not lie below parent material thickness.

4.13.2 After the X-ray and fluorescent penetrant inspections, the sequences are approved by inspection and the FAIR book is documented.



4.13.3 Chem-film is applied to the inboard and outboard sides of the weld as follows:

- a. The weld land is wiped, using acetone on a cheesecloth pad,
- b. The area is oxidized using a Bear-Tex pad and rubbing lightly by hand.
- c. The area is wiped clean with a cheesecloth pad and the Chem-film solution is applied by a mechanic wearing rubber gloves.
- d. After 3 to 5 minutes the excess solution is removed using a cheesecloth pad and deionized water.
- e. The Chem-film is allowed to dry a minimum of 12 hours and black vinyl corrosion preventive tape is applied.
- f. Inspection verifies Chem-film application and removal in the FAIR book.



5.0 CYLINDER 2 TO CYLINDER 1 CIRCUMFERENTIAL WELD

5.1 GENERAL DESCRIPTION

5.1.1 Cylinder 2 is welded to Cylinder 1 to make the lower cylinder assembly which is subsequently welded to the common bulkhead assembly. The Cylinder 2 to Cylinder 1 weld is performed in Station 1A with Cylinder 1 mounted on an adapter (Figure 5-1). The cylinders are rotated and the weld is made by two stationary weld heads located 180 degrees apart. The weld joint is a square butt configuration. The weld joint offset is controlled by an internal circumferential sizing tool (T-7204223).

5.1.2 Reference documents applicable to this procedure are as follows:

V7-332002	LH ₂ Tank
V7-332742	Lower Cylinder
V7-332743	Lower Cylinder 1/4 Panel Skin
V7-332744	Lower Cylinder 1/4 Panel Skin
V7-332745	Lower Cylinder 1/4 Panel Skin
MA0107-016	Machine Fusion Welding of Aluminum Alloy, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-Films
971-D-00237	Weld Schedule
TOS-556-005	Circumferential Sizing Tool - Circumferential Weld
TOS-556-008	Turntable Circumferential Welding
TOS-556-0027	Offset Measuring Tool - Circumferential Weld
MHP A-51-S-II	Position LH ₂ Cylinder 1 on Tooling Fixture
MHP A-52-S-II	Position LH ₂ Cylinder 2 on Cylinder 1 in Tooling Fixture, Using the Pneumagrip
MHP A-53-S-II	Remove LH ₂ Cylinder 1 and 2 Assembly from Tooling Fixture, Using the Pneumagrip
MHP C-66-S-II	Move Cylinder 1 LH ₂ Cylinder from Storage to VAB
PRO 565-017	Circumferential Weld Cylinder 1 to Cylinder 2

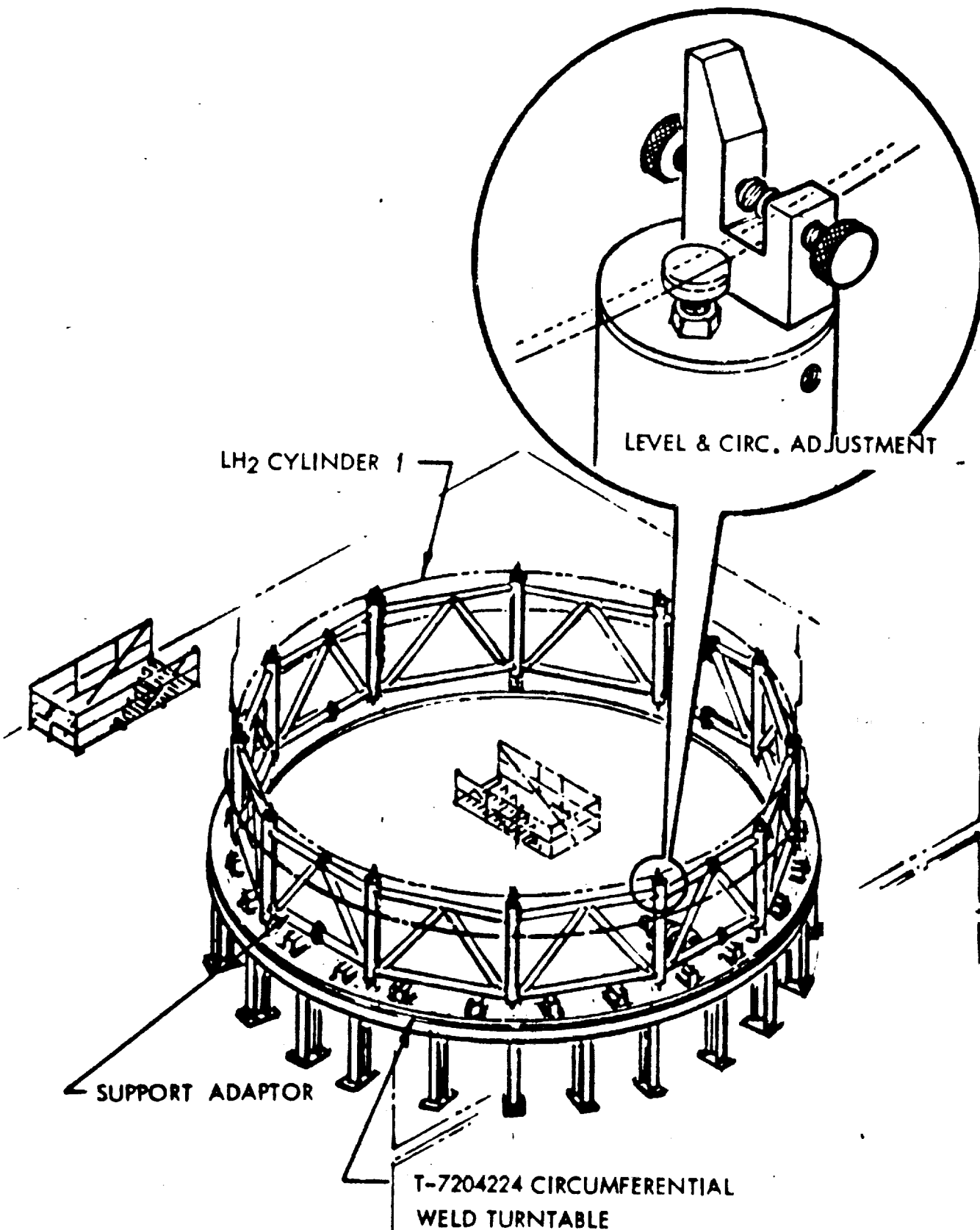


Figure 5-1. Adapter on Rotation Tool



- | | |
|---------------|--|
| MHP C-89-S-II | Move LH2 Cylinder (2-6) Assemblies from
Weld Fixture T-7200001 to Storage/VAB/
Weld Station 1A Using Pneumagrip and
5223 Adapters |
| MHP C-64-S-II | Move Cylinder 1 LH2 Cylinder Assembly From
the Weld Jig Fixture T-7200001 to Storage
and Weld Station in BFB |

5.2 LOADING THE STATION

5.2.1 The adapter (T-7204224-3301) is installed on the rotation tool (T-7204224). This operation is performed by Material Handling and Tooling personnel. The four turnbuckles located at the bottom of the adapter are attached to the rotation tool with four ball lock pins. The 16 ground cables on the adapter are attached to the grounding pigtailed on the rotation tool. The clevises on top of the 12 support posts are opened to accommodate Cylinder 1.

5.2.2 Using the overhead crane, the cylinder is loaded on the adapter (T-7204224-3301) in accordance with MHP-C-64-S-II. The lower edge of the cylinder is located in the Teflon-covered clevises on the 12 support posts.

5.2.3 Cylinder 1 is centered on the support posts by adjusting the two Teflon-protected screws on the clevises of the support posts. The space between the cylinder and all 12 clevises are equalized by manipulating the adjusting screws on the inboard and outboard side of the cylinder (Figure 5-2).

CAUTION

Do not use metallic bars or any tool which will scratch or mar the cylinder to pry the cylinder into center position.

5.3 LEVELING THE CYLINDER

5.3.1 The leveling tool (T-7204291) is clamped to the weld skate track and the indicator is adjusted so that the probe end is centered on the upper butt face of the cylinder. The dial indicator height is set to allow approximately 0.100-inch travel up or down, and the dial face is set to zero (Figure 5-3). The cylinder and rotation tool are checked for clearance prior to rotating. All electrical cords, hoses, cables, etc., are stowed away from the rotating equipment.

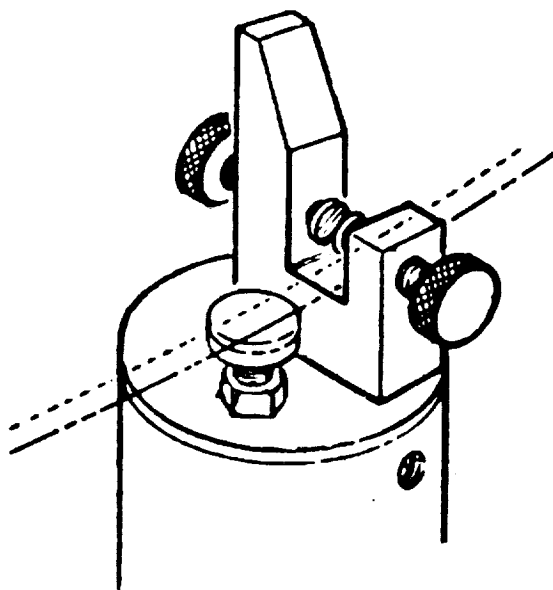


Figure 5-2. Leveling and Circling Adjustment

5.3.2 The rotation control box is connected to the power panel on the first floor. The control box safety key must not be in the control box. The speed control is set to 20-inch-per-minute travel and the turntable clearance reverified.

5.3.3 All personnel are notified to stand clear. The key is inserted in the control box and the turntable rotation is started. The level of the cylinder upper surface is monitored using a dial indicator. The cylinder must be level to within ± 0.030 inch (total indicator deflection 0.060 inch). If the cylinder is level within tolerance, Inspection verifies and clears the FAIR book sequence.

5.3.4 If the cylinder is not level, the jack screws at each support post are adjusted (Figure 5-3). The high point of the cylinder, as shown by the dial indicator, is used as a base and the remaining points are brought into tolerance. After tightening the lock nuts on the jack screws, the level of the cylinder is reverified within ± 0.030 inch. Inspection will verify and clear the FAIR book sequence.

5.3.5 Support saddles are positioned at 12 equally spaced points on the top edge of Cylinder 1. The saddles are checked before installation to be sure they do not scratch or mar the cylinders (Figure 5-4).

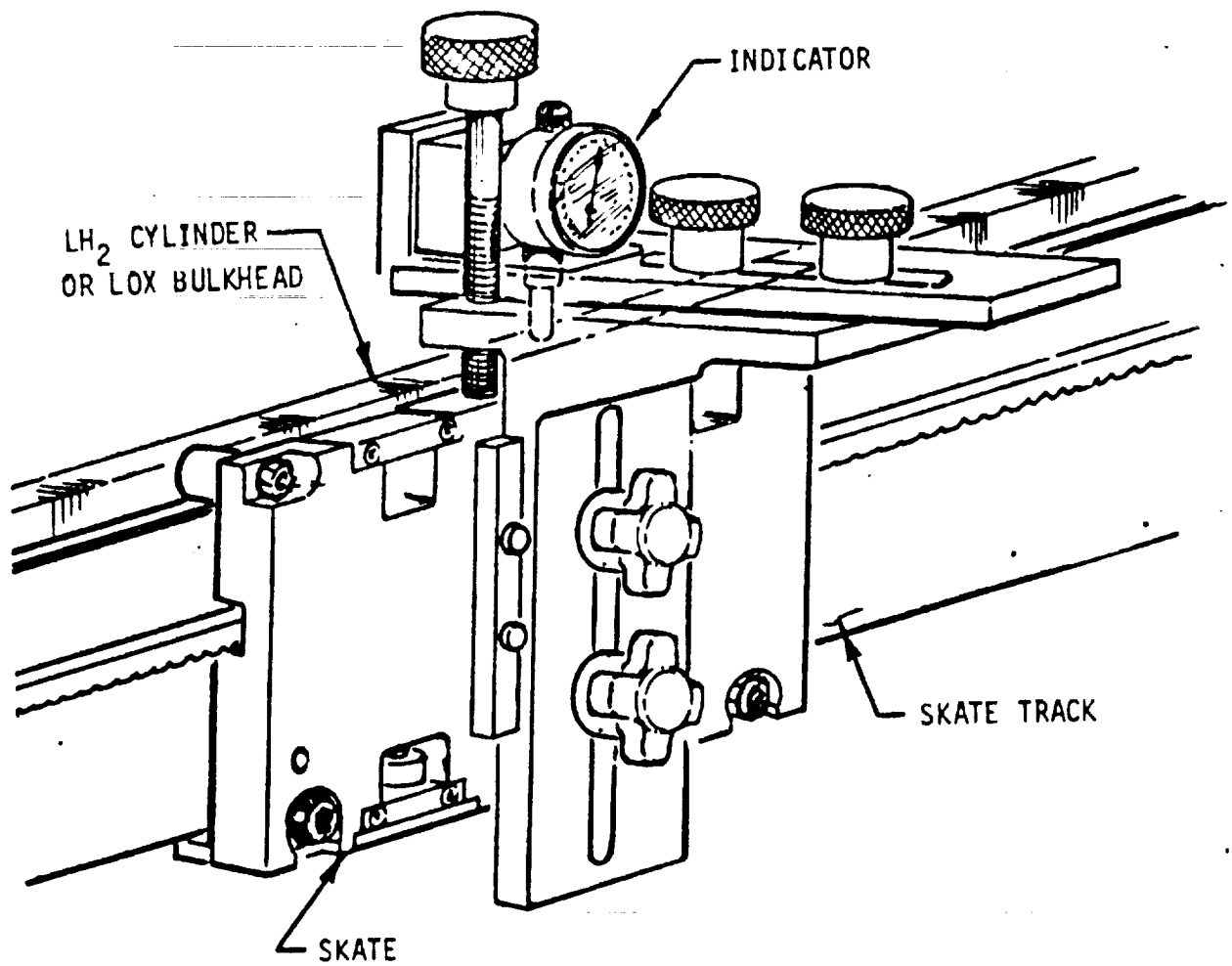


Figure 5-3. Leveling Cylinder

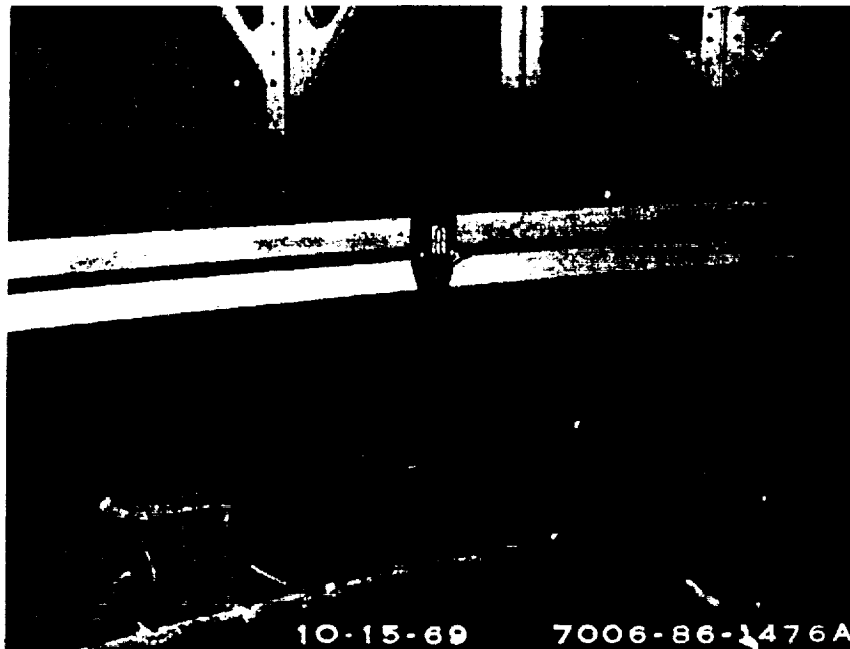
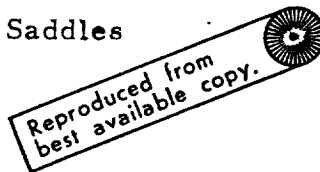


Figure 5-4. Cylinder Resting on Saddles



5.4 POSITIONING CYLINDER 2

5.4.1 This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has a responsibility to assure adherence to safety practices. The move conductor must be in attendance during all phases of the move.

5.4.2 Cylinder 2 is loaded into the saddles on Cylinder 1. Manufacturing personnel are positioned at 6 equally spaced areas to guide the bottom edge of Cylinder 2 into the saddles. The cylinder and handling fixture must be balanced to maintain a level plane within 1 inch during the loading operations (Figure 5-4).



Do not allow the edge of the cylinder to bump the saddles or any equipment such as the skate tracks.

5.4.3 As the cylinder is being lowered, the rotational alignment of the two cylinders is held by aligning Position I or the systems tunnel attach holes. Rotation need be held only within $\pm 1/2$ inch at this time. The



systems tunnel is approximately 6 feet counterclockwise from Postion I (Figure 5-5).

5.4.4 The move conductor and inspector clear all material handling sequences in the FAIR book and clear all rigging equipment from the station.

5.5 PREPARING STATION FOR WELD OPERATIONS

5.5.1 Riggers move the bridge crane to the west end of station and raise the curtain by means of a winch located on the first floor outside the station. After the curtain is secured, air temperature is checked. Temperature in the weld station should be 78 F minimum. Using the humidigraph located on the second floor, a humidity reading is taken; it may not exceed 50 percent. If the temperature or humidity exceed the allowable tolerances, Maintenance is called to correct the condition.

5.5.2 The first and second floors are wet-mopped and all bench tops, bin tops, and exposed beams in the station dusted. The shoe brush in the airlock entrance to the station also is checked for proper operation. The intercom system and phones, inboard and outboard of the cylinders, are connected.

5.6 PREPARING FOR WELDING

5.6.1 Two-inch lengths of Mylar tape are applied around the circumference on the inboard side. The bottom edge of the tape is positioned 8 inches below the butt edge of Cylinder 1. Tape is applied on each quarter-panel, 1 foot from each vertical splice weld, left and right, and one piece of tape in the center of the panel. These tape markers will be used to position the lower vacuum support chucks.

5.6.2 The dust is wiped from the vacuum chucks on the circumferential sizing tool (T-7204223-401). Acetone and cheesecloth are used to wipe the surfaces. Acetone is highly flammable and caution should be used during this operation. Only approved containers and plastic bottles are to be used (Figure 5-6).

5.6.3 The hydraulic manifold is laid on the platform floor inside the cylinder and the pigtail leads connected to the rotating boom arm pigtail leads.

5.6.4 One set of lower vacuum chucks is positioned on the inboard wall of the Cylinder 1. The top edge of the vacuum chucks must be kept level to the bottom edges of the Mylar tapes, 8 inches below the butt edge of the cylinder. The first chucks on the ends of the tool must be centered between the first and second vertical grids from the vertical welds on Cylinder 2. Three

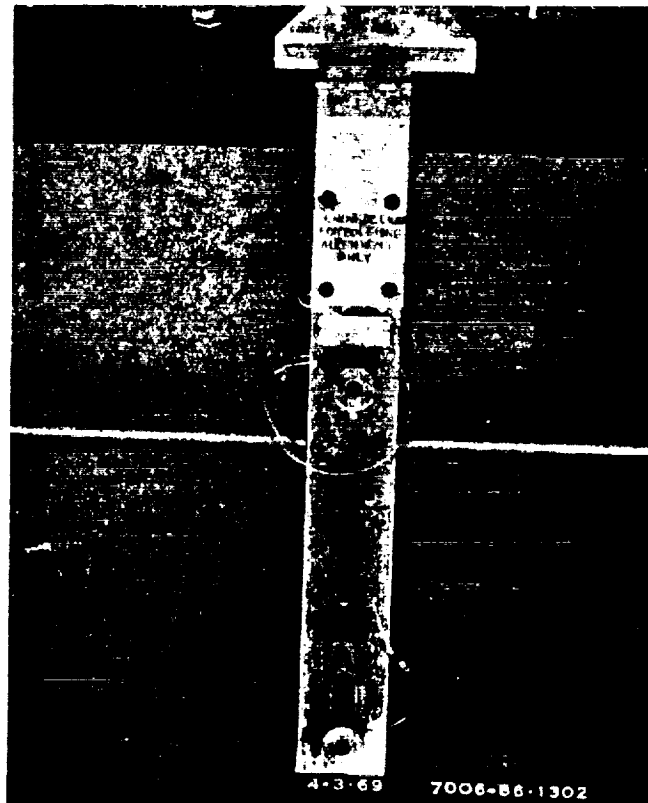


Figure 5-5. Rotational Alignment Tool

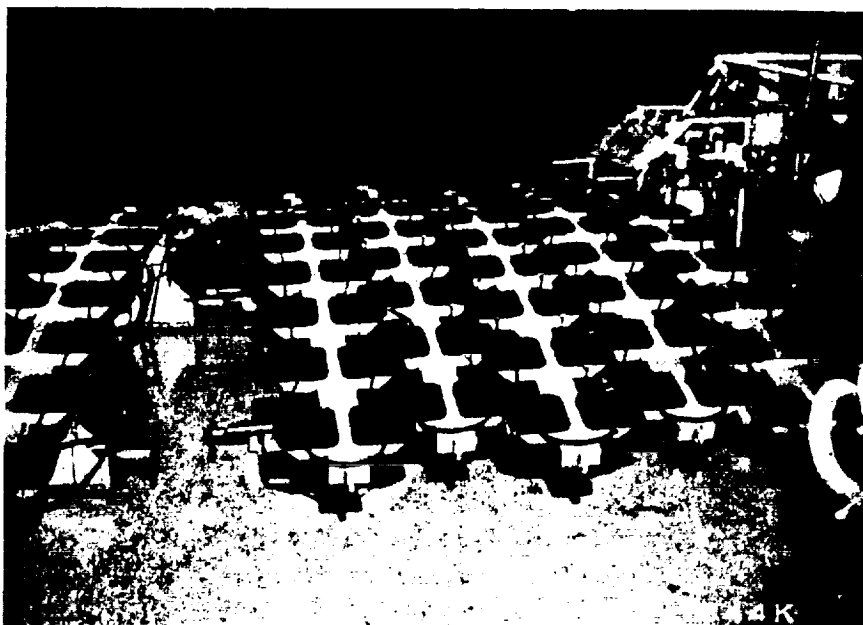


Figure 5-6. Preparing to Clean Vacuum Chucks



men are required to position the chucks (Figure 5-7). As the chucks are aligned to the cylinder, the vacuum line from the chucks is hooked to the vacuum manifold and the line opened to vacuum to secure the chuck. The chucks are tapped lightly to help seat them and prevent vacuum leaks (Figures 5-8 and 5-9). The 8 chucks are aligned around the cylinder and the vacuum system is checked for leaks.

5.6.5 Spreader links are installed between the ends of the 8 vacuum chucks. The ends of the spreaders are attached to the chuck frame with a ball lock pin in each end (Figure 5-10). The 8 spreader links are expanded by hand to form a full circle of the vacuum chucks and help to support the chucks in event the vacuum supply fails.

5.6.6 Eight safety poles are installed between the vacuum chuck frame and the base of the tool. The saddle end of the pole is positioned at the intersection of the center vacuum chuck bracket and the frame channel (Figure 5-11). The height of the pole is adjusted by loosening and retightening the slip joint at the approximate center of the support pole. The pole must fit snugly between the vacuum chucks and the rotation tool surface.

5.6.7 The first upper vacuum chuck is positioned on Cylinder 2. The vacuum chuck cup is positioned between the first and second vertical grids from the vertical welds. The bottom edge of the chuck must be in a horizontal plane approximately 2-1/2 inches above the lower horizontal rib. As the chucks are aligned to the cylinder, the vacuum line from the chuck is connected to the vacuum line on the lower chucks by the quick-disconnect fittings. After applying vacuum, the chucks are tapped to seat the vacuum cups (Figure 5-12).

5.6.8 The 8 upper chucks are aligned around the cylinder and the vacuum system is checked for leaks.

5.6.9 Spreader links are installed between the ends of the 8 upper vacuum chucks. The ends of the spreaders are attached to the chuck frame with a ball lock pin in each end. The 8 spreader links are expanded by hand to form a full circle of the vacuum cups and help to support the chucks in case of a vacuum failure.

5.6.10 The 16 control arms (A) are installed in lower support chuck bearings (B) as shown in Figure 5-13. The horizontal arm (C) on top of control arm is adjusted inboard and outboard by means of the adjusting screw (D) until the pin (E) can be installed through the upper vacuum support channel. The bolt on clamp F is loosened, if required, to allow the control arm to be raised or lowered.



Figure 5-7. Positioning Vacuum Chucks

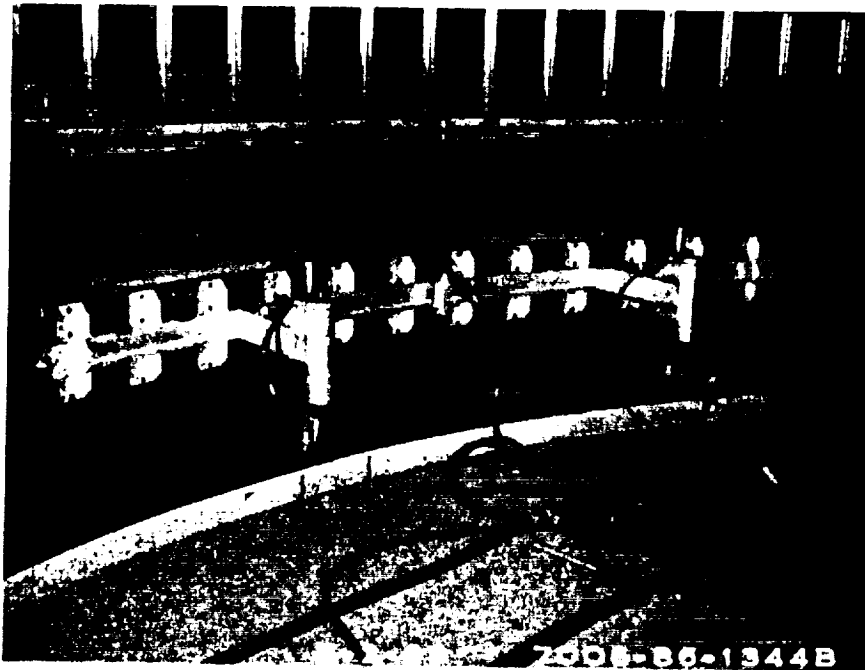


Figure 5-8. Vacuum Chucks Installed



Figure 5-9. Attachment of Vacuum Line to Manifold

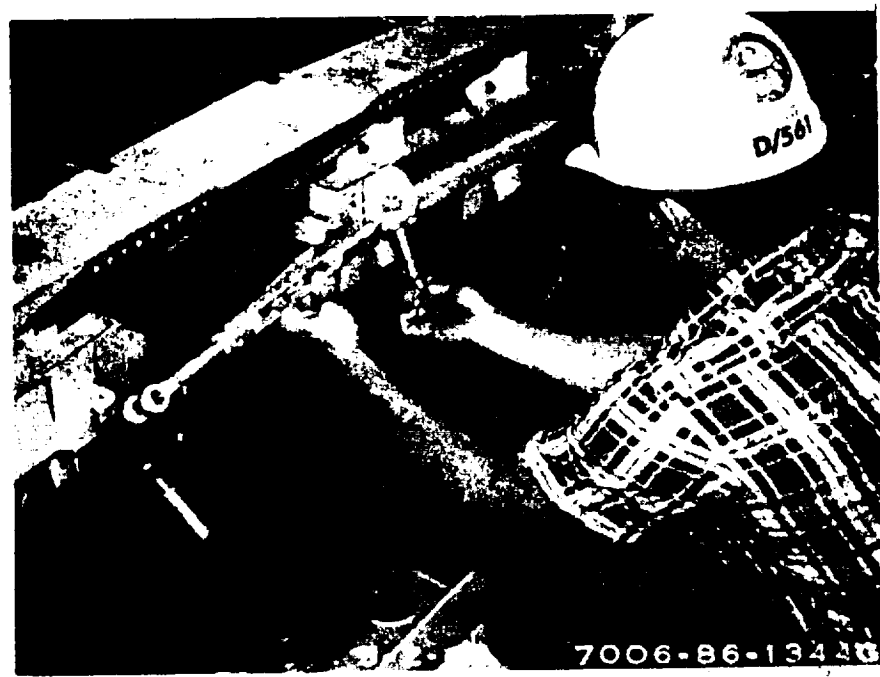


Figure 5-10. Spreader Link Installation

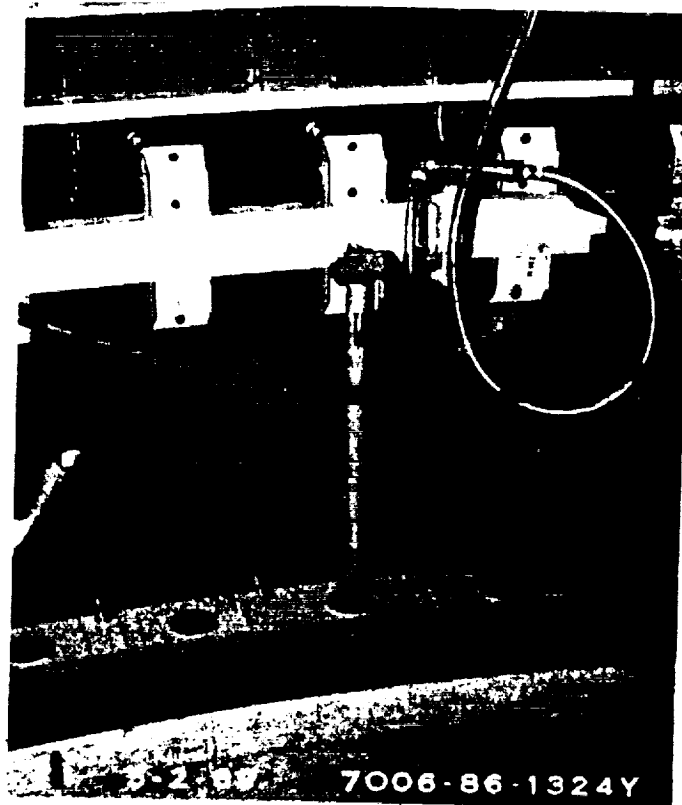


Figure 5-11. Support Poles for Vacuum Chucks

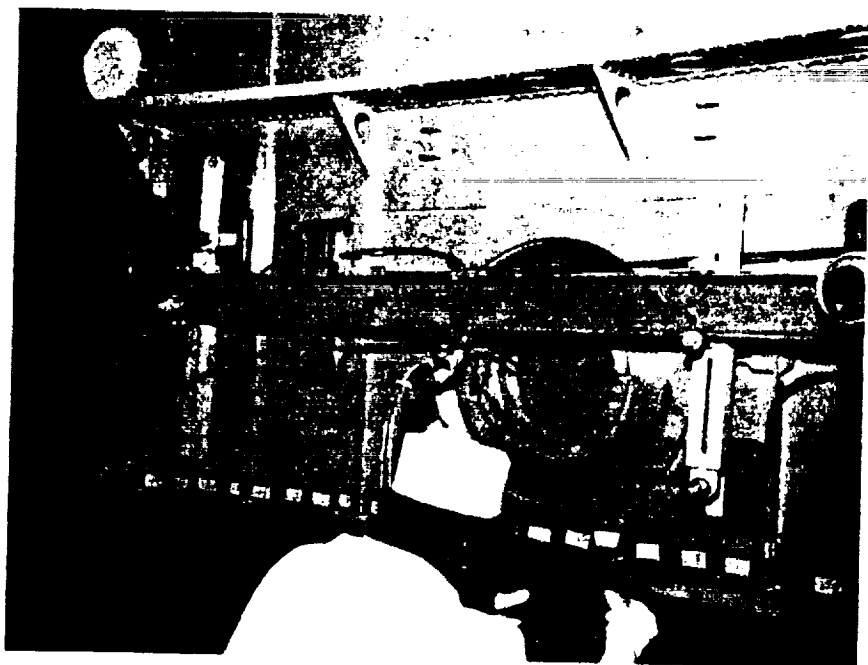


Figure 5-12. Upper Vacuum Chuck Installation

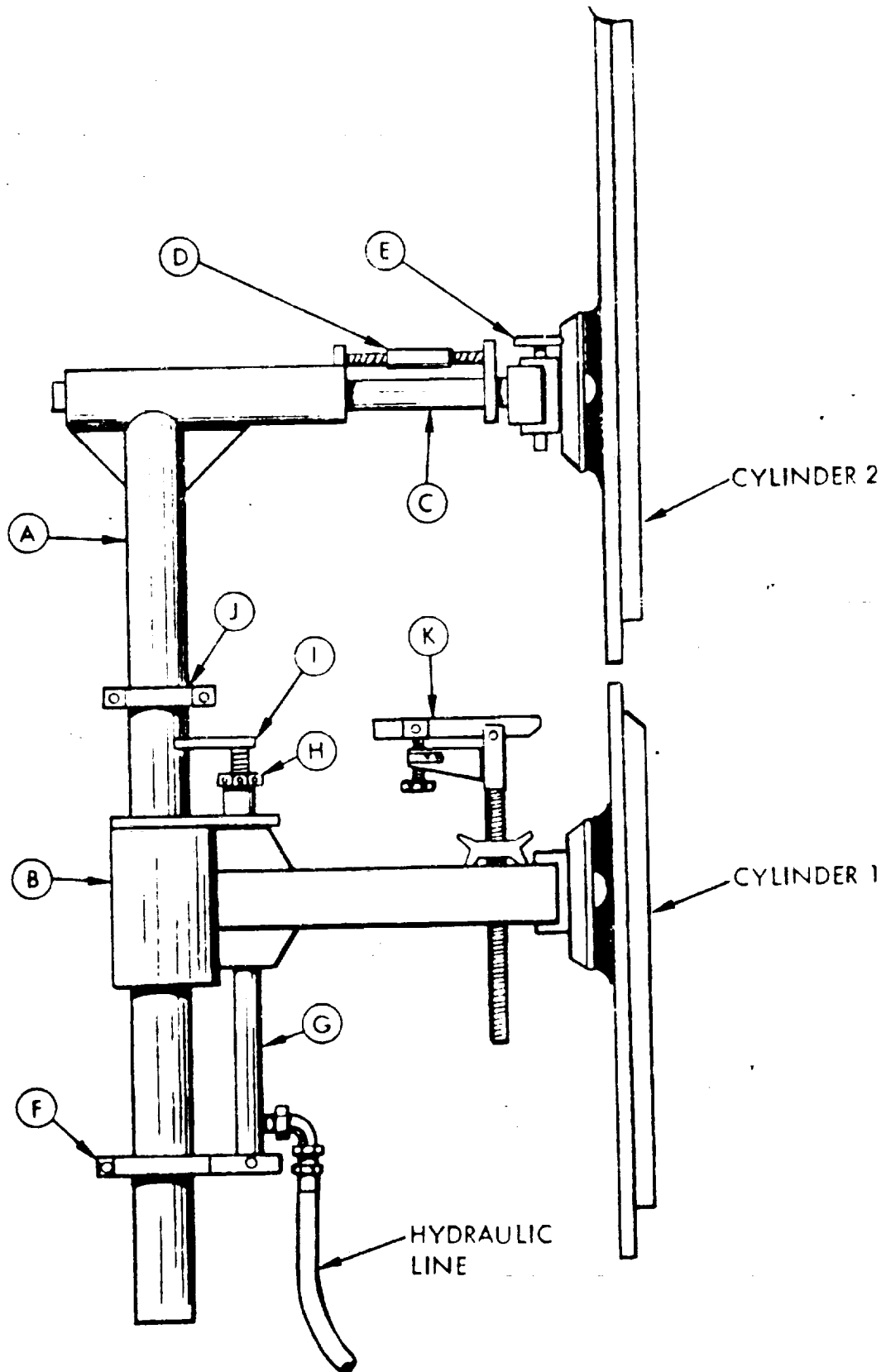


Figure 5-13. Vacuum Chucks



5.6.11 Hydraulic lines from the cylinders (G) are connected to the manifold and rotating boom. With clamp F still loosened, extend hydraulic cylinder G 12 inches. This setting is used with the cylinder still resting in the support saddles. Clamp F is then tightened on control arm A. The spanner nut (H) is rotated until 1 inch of thread shows between the spanner nut and support plate (I). Clamp J is loosened and lowered until it rests on support plate I, then retightened. All 16 support posts are set using these procedures.

5.6.12 The tooling and Cylinder 2 are checked for clearance before raising Cylinder 2.

5.6.13 The hydraulic reservoir is connected to the plant air supply. The sequence procedure posted on the hydraulic supply pump is used to raise Cylinder 2 until a 6-inch gap exists between Cylinder 1 and Cylinder 2 (Figure 5-14). Safety blocks are clamped to Cylinder 1 and Cylinder 2 at four equal spaces at the four vertical weld land areas (Figure 5-15).

CAUTION

Protect the C clamps with foil or Teflon pads to prevent damage to the weld land. Wash the spacer blocks with acetone before installing.

5.6.14 Numbered strip tape is applied below the weld land area on the outboard side. The strip is numbered every 3 inches starting at zero. When applying the strip, locate the zero mark at Position I on Cylinder 1. Use approved tape to hold the numbered strip to the cylinder (Figure 5-16).

5.6.15 One-inch Mylar tape is applied 2 inches above the lower horizontal rib on the inside of Cylinder 2. The tape is applied between the vertical ribs around the entire circumference (Figure 5-17). Masking tape is then applied over the Mylar tape.

CAUTION

Do not apply masking tape to the cylinder wall. Apply only over the Mylar tape.

5.6.16 The inboard tape is marked in 3-inch increments starting with zero at Position I. The inboard marks must align with the outboard marks on Cylinder 1.

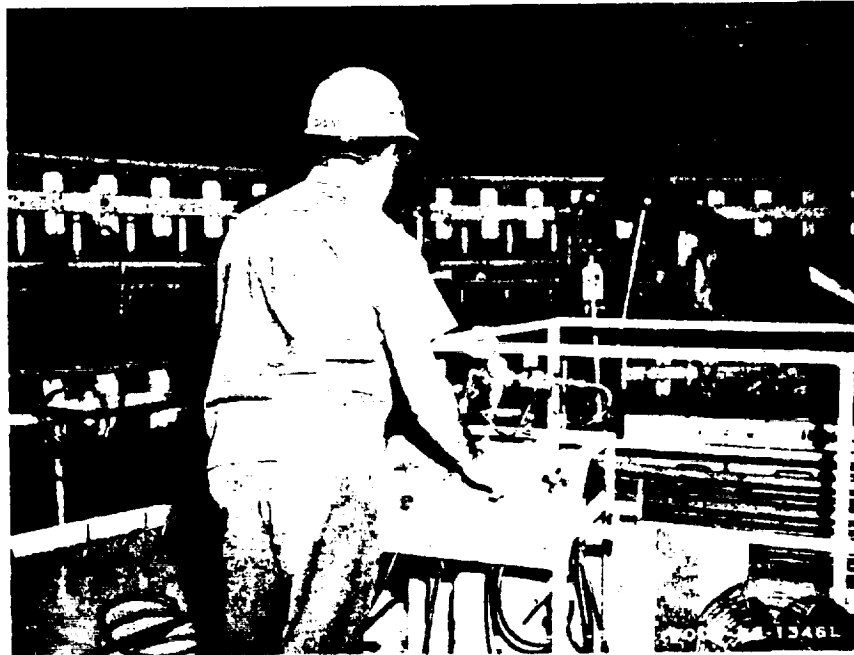


Figure 5-14. Hydraulic Pump for Raising Cylinder



Figure 5-15. Spacer Block Installation

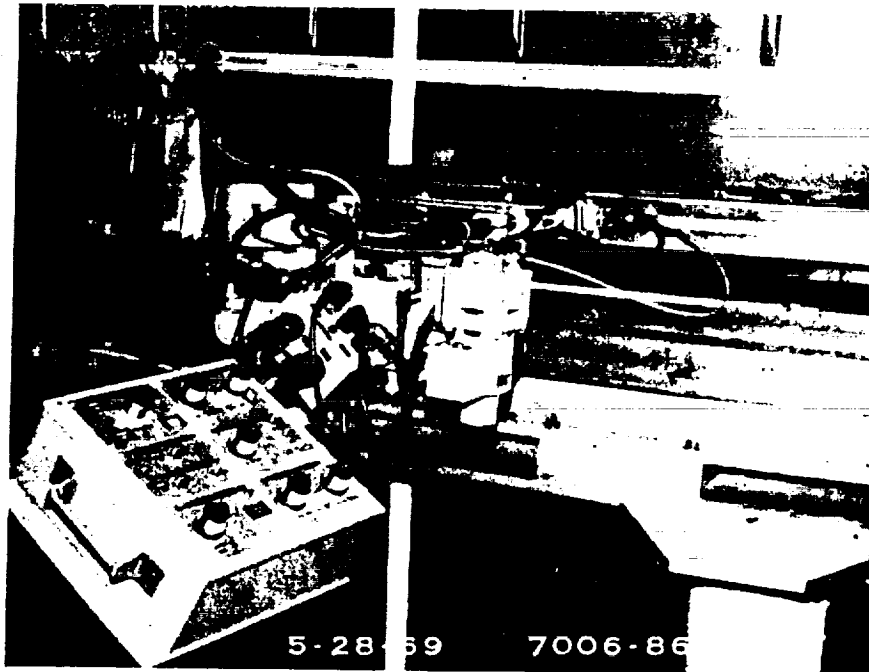


Figure 5-16. Installation of Tape (3-Inch Marked) Outboard

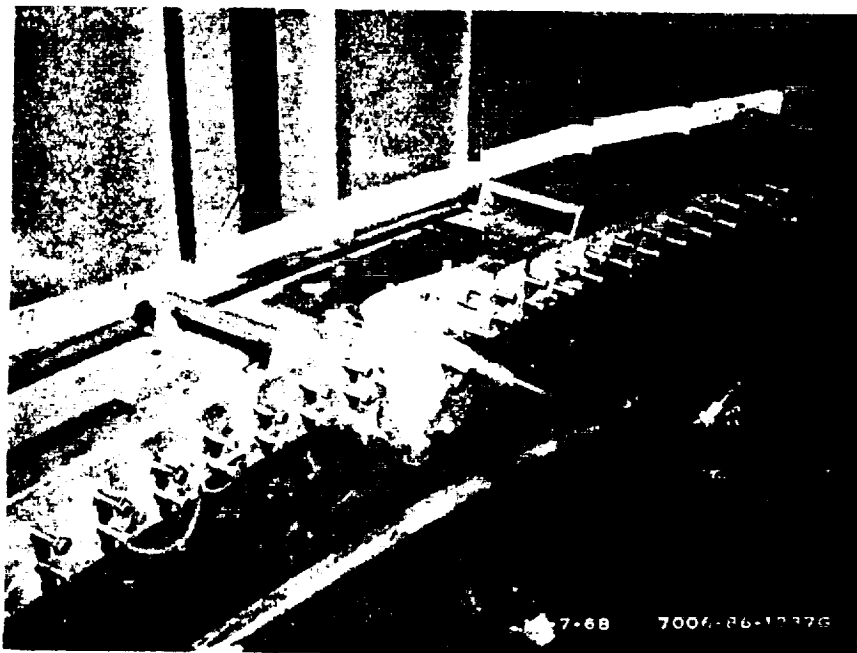


Figure 5-17. Marked Tape Applied Inboard



5.6.17 A thickness check will be performed by Inspection on Cylinders 1 and 2 on the weld lands at each 3-inch increment. The measurements, taken with a micrometer, are logged in ITI-SB121. Out-of-tolerance areas which are undersize are submitted to Material Review for disposition; those oversize are draw-filed to tolerance (Figure 5-18).

5.6.18 Inspection logs the pi-tape readings of Cylinder 1 and 2 circumferential weld lands in the FAIR book. These readings were taken previously in the bulkhead building after the cylinders were trimmed. Any dimensions out of tolerance are submitted to Material Review for disposition.

5.7 VERIFICATION PANELS

5.7.1 Verification panels are run prior to preweld cleaning as described in Section 1.14.

5.8 PREWELD CLEANING

5.8.1 Preweld cleaning operations are performed as described in Section 1.12.

CAUTION

Only personnel qualified for preweld cleaning are to clean the weld joint area.



Figure 5-18. Checking Weld Land Thickness



5.9 WELD TOOLING SETUP

5.9.1 During the precleaning operations the 8 circumferential sizing tools are washed with clean cheesecloth dampened with acetone. The circumferential sizing tools are checked for nicks and burrs on the fingers which come into contact with the weld lands. Any defects are removed with a mill file and the bars washed with acetone and clean cheesecloth. The circumferential sizing tools are wrapped with kraft paper until ready for use.

5.9.2 The 16 supports (K) are installed in the lower supports (B) as shown in Figure 5-19. The height is adjusted using wing nut L. The top of the crossbar should be set 2 inches below the top edge of Cylinder 1.

5.9.3 The center T-supports are installed on the channel of the lower vacuum chuck by hooking over the top flange of the channel. The set screw is then adjusted to level the top of the support. The height is adjusted using the wing nut. The top of the crossbar is set 2 inches below the top edge of Cylinder 1. One of these supports is installed in the center of each of the bottom vacuum chuck assemblies (Figure 5-20).

5.9.4 After the precleaning of the cylinders is completed, all chips are vacuumed from the area.

5.9.5 Circumferential sizing tools (T-7204223) are installed onto the T-supports using the hydrolift crane. An adapter (T-7204223-903) is attached to the circumferential sizing tool by means of three pins. Two of the pins attach into the back flange of the tool and one through the center web. The adapter is then tied to the hook of the hydrolift crane located on the second-floor level on the inboard side of the cylinders. The turntable is rotated so that the first circumferential sizing tool can be set on the T-supports of the lower vacuum chucks (Figure 5-21).

CAUTION

Check turntable clearance before rotating table. Check all hoses (vacuum, hydraulic, etc.) for clearance before rotating table.

5.9.6 The first circumferential sizing tool is hoisted with the hydrolift and positioned on the T-supports, centering the circumferential sizing tool on the lower vacuum chucks. The turntable is rotated and the remaining 7 circumferential sizing tools are hoisted into position.

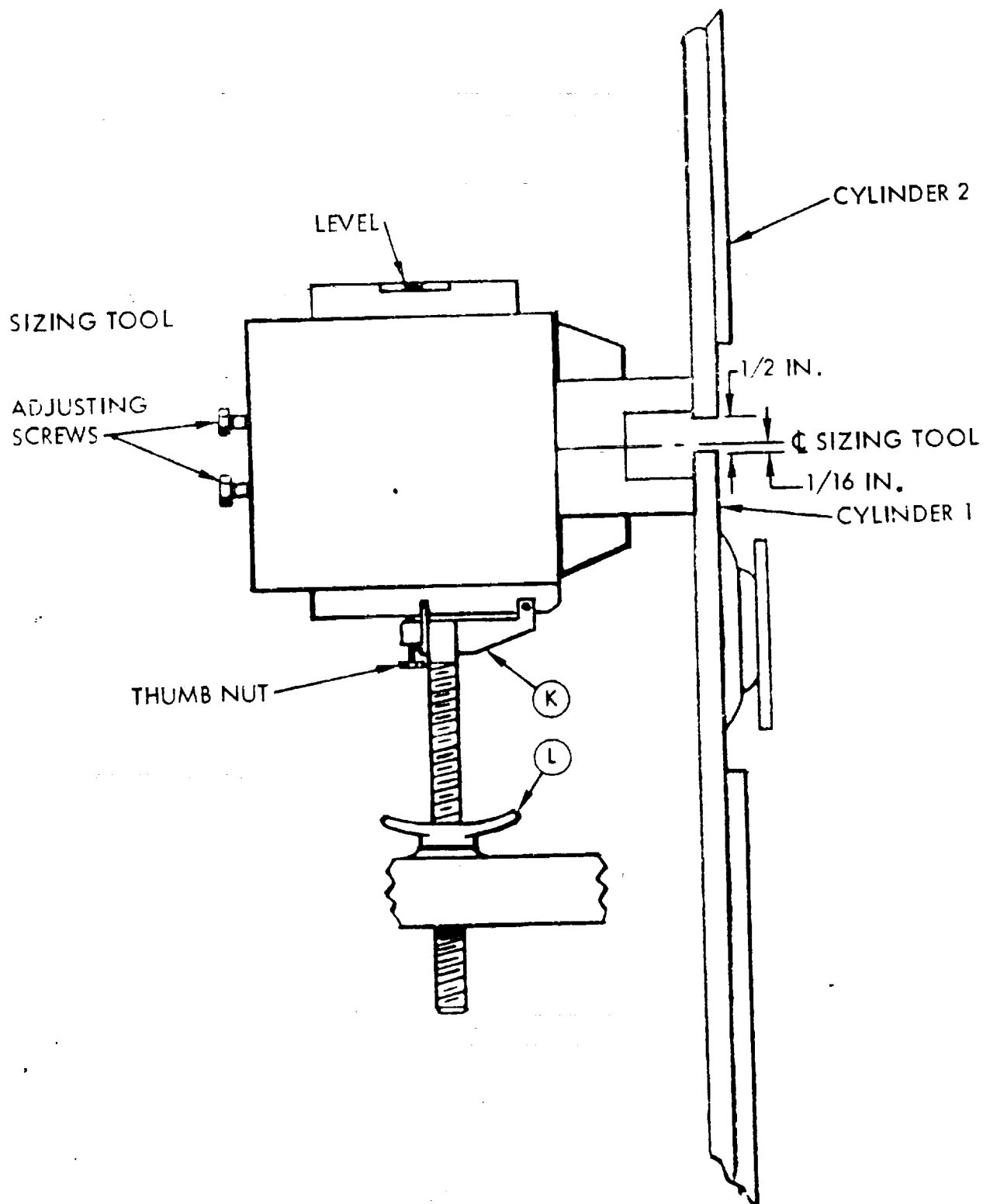


Figure 5-19. Height Adjustment



Figure 5-20. Installation of Center Sizing Tool Supports

5.9.7 The spreader jacks (T-7204223-381) are installed between the circumferential sizing tools at 8 places. The jacks are attached by means of 1/2-inch diameter ball lock pins through the slotted holes. It may be necessary to pry the last two tools apart in order to install the last spreader jack. A turnbuckle placed between the ends of the circumferential sizing tools and then expanded will force the sizing tools far enough apart for the spreader jack to be installed. Circumferential sizing tools must not contact the cleaned edges of the cylinders (Figures 5-17 and 5-22).

5.9.8 Dust caps are removed from the end of the hydraulic lines attached to the spreader jacks and the lines are connected to the hydraulic manifold lines. The valves are opened after hooking the hydraulic line into the system. If the spreader jacks have not been previously wrapped in plastic, it is wrapped around them to prevent hydraulic oil from contaminating the cleaned weld surface in case of hydraulic oil leaks (Figures 5-17 and 5-22).

5.9.9 The height of the circumferential sizing tool is checked. The top edge of Cylinder 1 must be no more than 1/16 inch below the centerline of the circumferential sizing tool (Figure 5-19). The height of the circumferential sizing tool is adjusted if required by means of the adjusting wing nut (L). The sizing tools are leveled by placing a spirit level on top of the circumferential sizing tool and adjusting the thumb nut on the support (K) (Figure 5-19).



Figure 5-21. Sizing Tool Positioned on T Supports



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Figure 5-22. Spreader Jack Installation



CAUTION

Do not contact the cleaned surfaces of the cylinders while leveling the circumferential sizing tools.

5.9.10 By means of the hydraulic jacks (G in Figure 5-13), Cylinder 2 is lowered over the circumferential sizing tool until a 7/16- to 1/2-inch gap exists between Cylinders 1 and 2. Clamp J should rest on plate I at the 12 locations around the circumference (Figure 5-13).

CAUTION

Follow instructions shown on the hydraulic console for lowering Cylinder 2. Only qualified personnel are to operate the pump. Use extreme care in lowering and continually check around the circumference so that the butt face of Cylinder 2 does not contact the circumferential sizing tool fingers.

5.9.11 The hydraulic system is pressurized to 3000 psig to expand the circumferential sizing tool. Follow the instructions displayed on the hydraulic console.

5.9.12 The above operation should occur near a shift change. The joint is covered with aluminum foil inboard and outboard. Only approved tape is used and care must be taken not to contaminate the joint area.

5.10 FINAL CLEANING

5.10.1 The following operations must be accomplished with all personnel wearing clean white smocks, caps, and nylon gloves. The aluminum foil is removed from the weld joint and the joint prepared as defined in Section 1.12.

5.11 FINAL WELD PREPARATION

5.11.1 After completion of the final cleaning operations, the rotational alignment tool (T-7204282) is installed. The alignment tool attaches to two of the tunnel left-hand attachment holes in Cylinder 1 and two of the left-hand holes in Cylinder 2 (Figure 5-5). The tool is provided with bushings with a 1/4-inch inside dimension and a 3/4-inch outside dimension. Special screws, 1/4-28, are provided with the tool. These screws are installed through the bushings which are slipped into the holes of the alignment tool. One of these holes in each half of the tool is slotted to allow for vertical tolerance between the tunnel attach holes.



5.11.2 The circumferential sizing tool pressure is lowered to 500 psig. Precleaned 0.040-inch stainless steel shims are installed at 12 equally spaced points around the circumference of Cylinder 1. The spacers are taped to Cylinder 1 below the cleaned area with Mylar tape. One leg of the shim, approximately 1/2- to 3/4-inch long, must rest on the Cylinder 1 butt edge, as shown in Figure 5-23. These shims are used to prevent Cylinder 2 from bearing on Cylinder 1 during the lowering and rotational alignment operations.

CAUTION

Preclean the shims with acetone prior to installation. Do not contaminate the shims during installation. Use only approved tape on the cylinder surface.

5.11.3 Cylinder 2 is lowered using a spanner wrench on the nuts (H) shown in Figure 5-13. The cylinder is lowered by turning the nuts counter-clockwise on the 16 support jacks (G). The cylinder lowering operation and rotational alignment are monitored from the cylinder outboard side.

5.11.4 Cylinder 2 is lowered to an approximate 1/8-inch gap around the circumference. Rotational alignment is checked by means of the pointer on the upper alignment tool (T-7204282) against the scale on the lower tool. Tolerance must be kept within 0.030 inch. The circumferential sizing tool pressure may have to be lowered to zero and Cylinder 2 rotated by personnel pushing from inside the cylinder. In extreme cases a cable hookup and turnbuckle can be used for rotation purposes (Figure 5-24).

5.11.5 The circumferential sizing tool is repressurized to 500 psi if the pressure has been lowered for rotation. Cylinder 2 is then lowered at Position I to approximately a 0.040-inch gap, the rotational alignment rechecked, and the circumferential sizing tool pressurized to 6000 psig.

CAUTION

Only qualified personnel are to operate the hydraulic pump. Verify rotational alignment by Quality Control and NASA inspection and clear item in FAIR book.

5.11.6 Approval to weld is verified in the FAIR book.

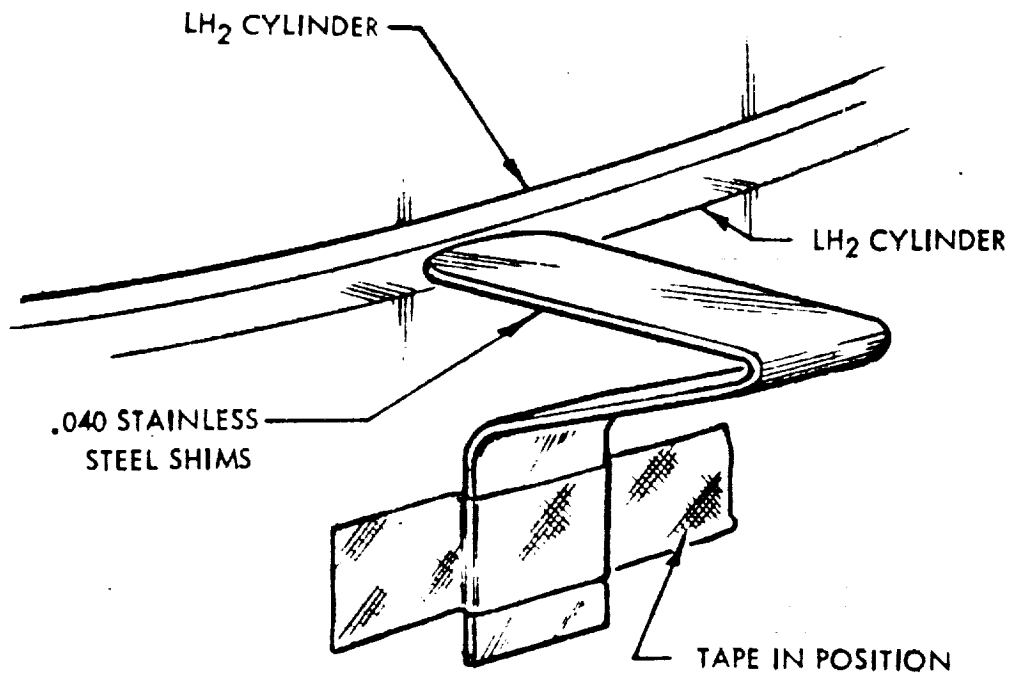


Figure 5-23. Stainless Steel Shims Installed

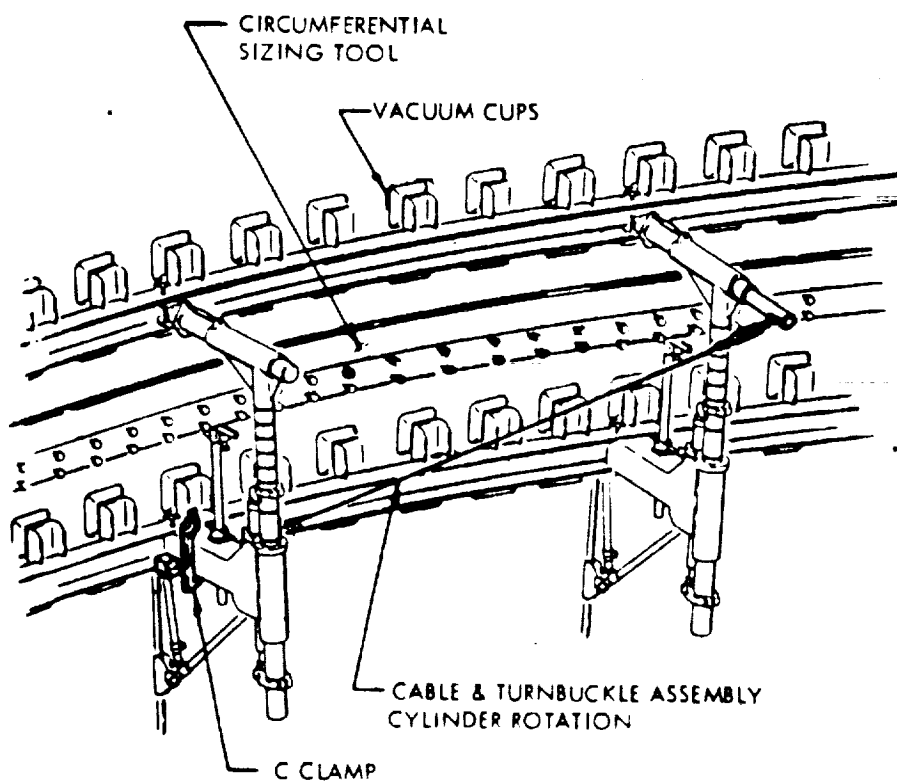


Figure 5-24. Use of Cable for Rotation



5.11.7 During the final cleaning operation the welders and the weld engineers verify the equipment. The gas is checked for moisture content, the wire is checked, and the heat treat number, size, etc., are logged in the FAIR book. A bead-on verification plate is run by the welder and checked by Quality Control, which also checks the machine settings to the 971-D-00237 Weld Schedule. The weld heads are then moved to the skate track at each weld position. The welder hooks the sensing and ground leads to the assembly, and these are checked by the weld engineer.

5.12 WELDING OPERATIONS

5.12.1 Two tack-weld teams are utilized for the circumferential welds. Each consists of a welder, an offset manipulator, and a vacuum hose operator outside the cylinder, and an offset manipulator on the inside. The two teams operate 180 degrees apart. Another team consisting of a man on the outboard side and a man on the inboard side for each weld station preset the offset ahead of the tacking crew (Figure 5-25). The weld machine parameters are set for the intermittent tack weld per the 971-D-00237 Weld Schedule.

5.12.2 Communication between the outboard and inboard side is by means of intercom headsets. Using a 0.050-inch thick stainless steel gauge, the manipulator checks the offset and informs the man on the inboard side which cylinder must be moved to arrive at a target of 0.010-inch offset. The inside man adjusts the offset by means of the bolts on the inboard side of the circumferential sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers.

5.12.3 The first tack is located at approximately Position 1 where a 0.040-inch gap exists. The offset is set by the manipulating team. The joint area is vacuumed to remove any foreign material from the faces of the cylinders. Care is taken not to touch the surfaces. The weld head is then moved into position for the first tack and locked to the gear rack on the track. The torch is positioned for the tack, the backup pressure of 6000 psi verified, and the first tack is made. A 3-inch long tack is run per the 971-D-00237 and the machine tapered out. A space of 6 inches is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for 4 or 5 tacks (Figure 5-26). The rotational alignment tools and the 0.040-inch stainless steel shims then are removed.

5.12.4 The gap around the cylinders is checked, and if the gap 180 degrees from the first tacks exceeds 0.040-inch, the circumferential sizing tool pressure is lowered to 500 psi. Cylinder 2 is then lowered to a 0.040-inch gap. If required the cylinders can be pulled together by means of a large clamping tool (Figure 5-27). The circumferential sizing tool is repressurized to 6000 psi.

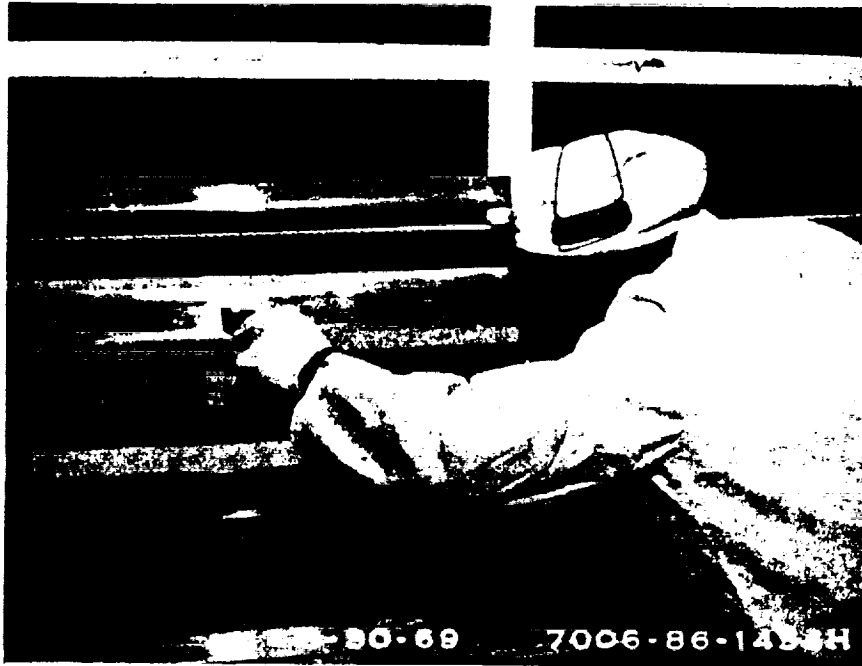


Figure 5-25. Checking Offset

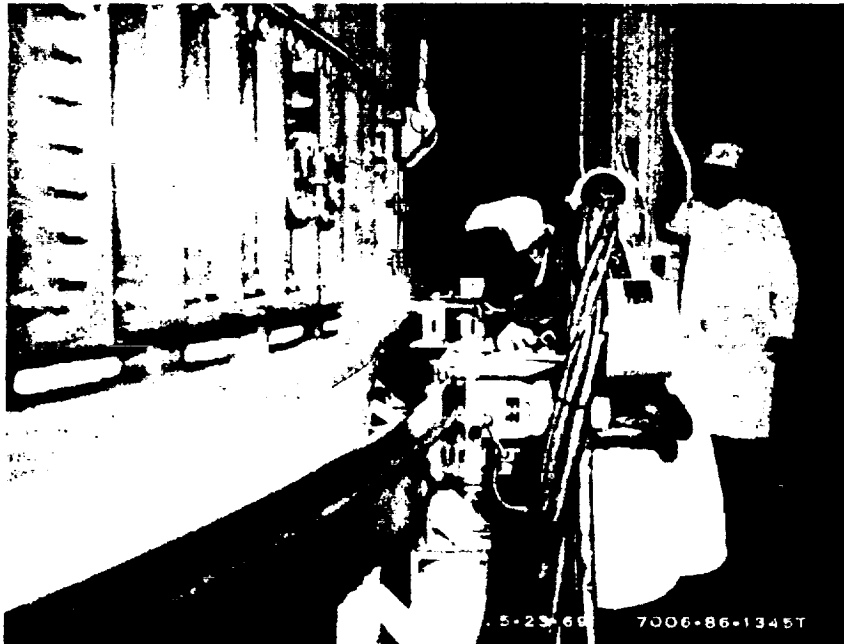


Figure 5-26. Intermittent Tack Welding

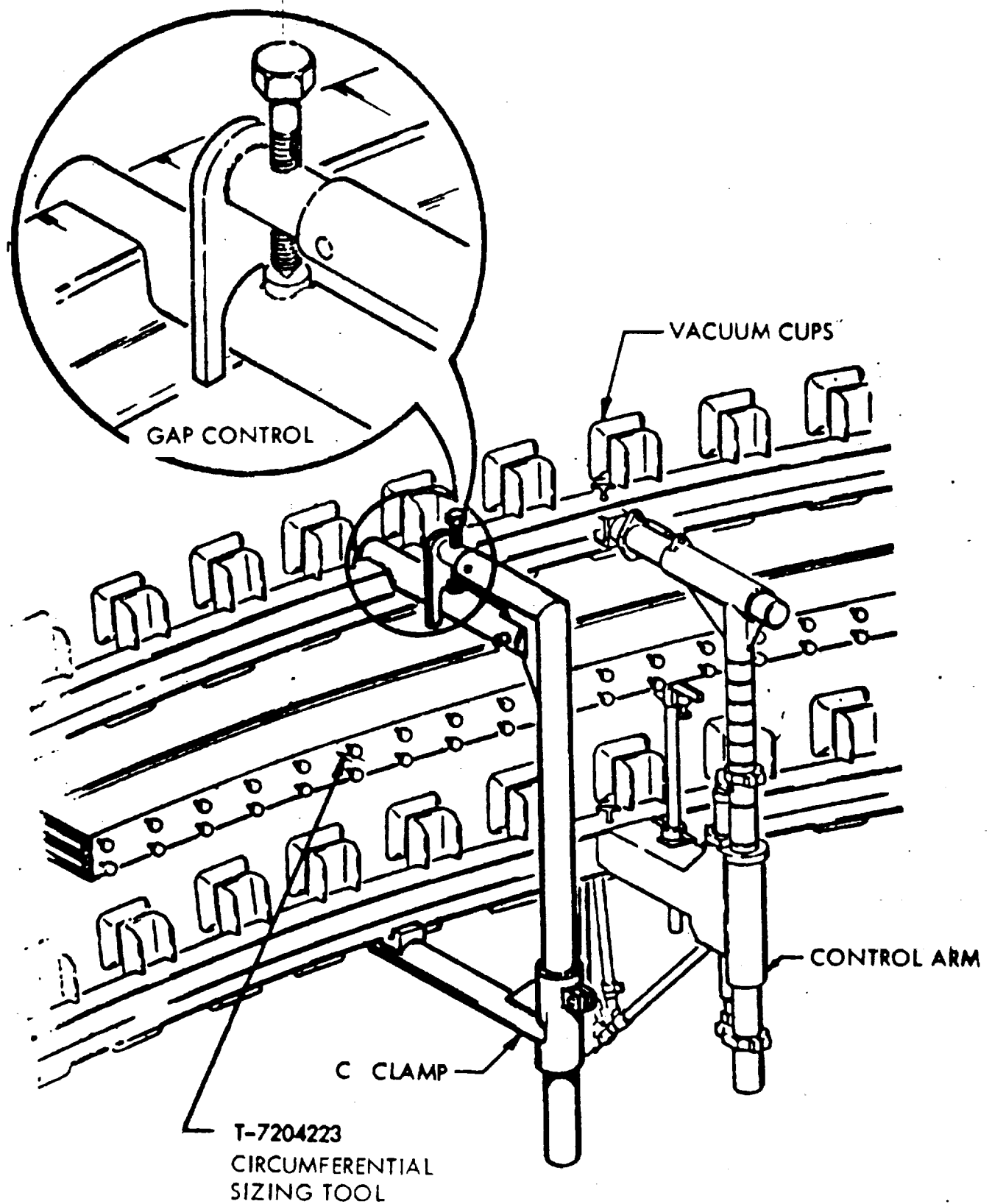


Figure 5-27. C Clamp for Drawing Cylinders Together



5.12.5 When the gap is determined to be 0.040-inch at Position III (180 degrees from the first tacks) the tacking operation can begin at the second weld position. The same offset alignment procedure is used.

5.12.6 The cylinders are welded at the two stations with 3-inch long tacks at 9-inch centers. When each weld machine has tacked the cylinders the full length of the skate track, approximately 8 feet, the turntable is rotated to allow a second series of tacks. The turntable is rotated to a new tack position 7 times. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.015 offset after welding is checked by supervision and will be reworked if required.

5.12.7 When intermittent tack operations are complete, the circumferential sizing tool centering is checked and the pressure dropped and the tool recentered on the weld joint if required. The tool is then repressurized to 6000 psig and all adjusting screws are backed off and readjusted finger-tight to assure contact of the sizing tool with the cylinders.

CAUTION

Do not over-tighten screws.

5.12.8 The weld machine parameters are reset for the continuous tack pass per the 971-D-00237 Weld Schedule. Turntable speed and direction of travel is verified. Turntable travel will be in a clockwise direction. An air motor with a 1/4-inch ball rotary file is set up at each weld station. This is to be used to grind out the minute crater cracks left when the weld machine sequences out after running the continuous tack pass.

5.12.9 The weld heads are positioned at the right-hand end of each skate track. Sufficient distance from the end is allowed to permit the skate travel to sequence-out the weld heads, in the event the turntable malfunctions. Weld heads are locked to the track and the travel potentiometer set for the correct skate speed. In the event the turntable stops, the welder must immediately switch on the skate travel switch and then sequence out.

5.12.10 A final check is made on turntable speed, direction of travel, weld machine settings, skate-to-track lock, and circumferential sizing tool pressure. A countdown is called out on the intercom, and at the words "sequence start," both welders energize their weld machines. As soon as both arcs stabilize, the turntable is started. In the event one machine fails to start, two courses are open to the supervisor or weld engineers: the operating machine can continue while the second machine is checked out for the cause of the misfire and then fired in a running start, or



the operating weld head can be sequenced out until the second machine is checked and then both machines restarted together.

5.12.11 The continuous tack pass is performed per the Weld Schedule and is made with each machine overlapping the start of the other machine for a minimum distance of 6 inches or until a good tie-in is made. As each machine sequences out for any reason, the tailout crater is ground out to a depth of approximately 0.060 inch with the ball rotary file. The turntable is not shut off until both machines have sequenced out. The crater is ground out as soon as the welding arc is terminated to eliminate small crack propagation.

5.12.12 As the continuous tack pass cools down, the circumferential sizing tools are again checked for centering and adjusted as needed. If the tools are moved, they are repressurized to 6000 psi.

5.12.13 Using a fine stainless steel rotary brush in an air motor, the entire cover tack pass is brushed. The brush is moved in long strokes in one direction only. Dust and soot are vacuumed from the area. The surface of the weld land must not be touched with any material except the wire brush.

5.12.14 The weld machines are reset for the penetration parameters per 971-D-00237 and verified by Inspection. The override control is moved to the inside of the cylinder and the control switch on the weld pack is turned on.

5.12.15 The following preparations for the penetration pass are checked and verified:

- a. Phone communications between inboard and outboard at each weld station.
- b. Circumferential sizing tool pressure and centering.
- c. Turntable speed and the direction of travel (clockwise).
- d. Availability of an air motor and a 1/4-inch ball rotary file at each weld station.
- e. Locking of weld head into the skate track and proper speed setting on the potentiometer at the pendant station.
- f. Skate lock in and override controls.



- g. Positioning of welders on inboard side and contact with the welders on the outboard side by means of the phones.

5.12.16 The countdown is started and at sequence start, both machines are energized. When the arcs stabilize, turntable rotation is started. The operator on the inboard side controls the amount of drop-through on the penetration pass and also is responsible for tracking the seam. The drop-through is watched by means of sight holes in the circumferential sizing tool (Figure 5-28).

CAUTION

Check cables on inboard side as boom rotates so they do not hang up.

5.12.17 The penetration pass is run per the 971-D-00237 Weld Schedule. Each machine will overlap the penetration of the other machine a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground out to a depth of approximately 0.060 inch. A visual check is made to verify that all tailout crater defects are removed.

5.12.18 The drop-through (inboard) side is checked for incomplete penetration. If any defective areas exist, the incomplete penetration area is rotated to the closest weld head. This weld can be picked up by either weld machine using the skate travel of the head instead of the turntable rotation.

5.12.19 White garments are not required for the following operations. After the penetration pass or pickup operations are complete, the circumferential sizing tool pressure is dropped and the 8 circumferential sizing tool spreader jacks are removed and stored neatly on the inboard side of the cylinders. The turntable is checked for clearance, both inboard and outboard. The turntable is rotated to position a circumferential sizing tool at the hydrolift. Using the hydrolift and adapter (T-7204223-903), the first circumferential sizing tool is removed and lowered to the floor. The turntable rotation is continued and the remaining 7 circumferential sizing tools are removed and stored. The 8 upper vacuum chucks and the 16 support arms (A) are then removed (Figure 5-13).

CAUTION

Do not remove the lower chucks.

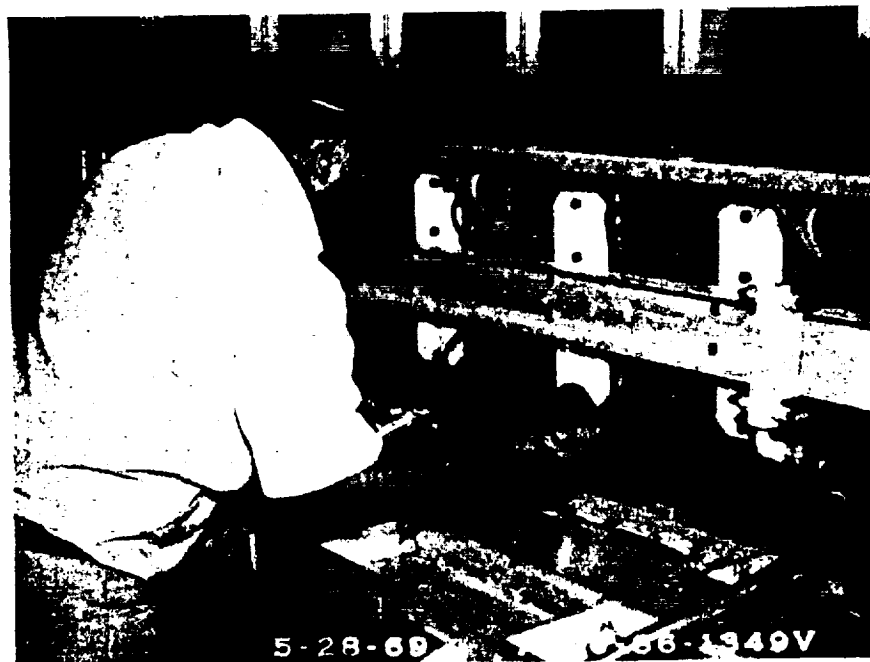


Figure 5-28. Monitoring Penetration Pass

5.12.20 The drop-through side of the weldment is inspected for undercut, incomplete penetration, folds, etc., per Specification MA0107-016. Inspection will verify the drop-through, usually by means of a reference squawk.

5.12.21 Using three or four weld shavers, the weld bead on the inboard side is milled to a height of 0.010 to 0.015 inch (Figure 5-29). Care is taken not to cut into the parent metal with the shavers. The inboard side of the weld is abraded with a Bear-Tex wheel in an air motor. Long, even-pressured strokes are used in abrading, with no pauses in any one area. Bear-Tex wheels are not to be run crosswise or at an angle to the weld (Figure 5-30).

5.12.22 A fine stainless steel rotary brush is used to remove the soot from the outside of the weld. The penetration side (outboard) is checked for any folds, etc., that can be blended out prior to X ray. Blending is with ball rotary files. The inboard and outboard sides of the weld are wiped using clean cheesecloth and acetone.

5.12.23 The weld penetration pass is X-rayed and the report prepared. Defects identified are evaluated by the Manufacturing supervisor and weld engineer to determine which should be reworked before putting the cover passes on the weld. A Manufacturing Request for Rework (Form 021S) is filed requesting planning tickets for in-process rework. Defective areas are repaired per procedures outlined in Section 10.



Figure 5-29. Milling Weld Bead



Figure 5-30. Abrading Weld Bead With Bear-Tex Wheel

5.12.24 The circumferential sizing tools are reinstalled following the procedures outlined in Steps 5.9.5 to 5.9.12, pressurized to 6000 psig, and checked for hydraulic leaks.

5.12.25 White garments must be worn during the following operation. The outboard side of the weld is brushed with a clean fine stainless steel rotary brush in an air motor. Long strokes in one direction only are used.

5.12.26 The parameters on the weld packs are reset for the cover pass weld per the 971-D-00237 Weld Schedule. The override control is to remain off. The weld head is locked on the skate track and the speed potentiometer is set for the proper speed. The circumferential sizing tool is checked for pressure, the turntable for speed and direction of travel, and the skate is locked on the track. An air motor with a 1/4-inch ball rotary file is positioned at each weld station.

5.12.27 A countdown is started and at sequence start both machines are energized. When the arcs stabilize turntable rotation is started and the first cover pass is run. The operator makes sure that the bottom edge of the penetration pass is covered by the first cover pass. The ends of the cover passes are to overlap at least 6 inches.

5.12.28 Sequence-out craters are ground out with the ball rotary file. The cover pass is wire-brushed and the entire circumference inspected for lack-of-fill areas. The decision is made whether to run a complete second cover pass or intermittent pickups.

5.12.29 The second cover pass is then run if required, using the operations per Steps 5.12.25 through 5.12.28. If intermittent pickups are required, the turntable or the skate track is used depending on the length of the area. After the second cover pass or intermittent pickups are made, the weld is inspected for defects.

5.12.30 The circumferential sizing tools are removed, following Step 5.12.19. Three or four weld shavers are used to mill the cover passes to 0.010- to 0.015-inch height. Do not touch the parent material. The milled weld bead is abraded with a Bear-Tex wheel, moving the wheel in long strokes. Do not abrade across the bead.

5.13 POST-WELD OPERATIONS

5.13.1 The entire weld is X-rayed, the film read out, and triangulation shots made of any questionable areas. Any rework required may be accomplished by the in-process method per Section 10, or by MR action. After X ray is complete, the joint both inboard and outboard is inspected with



fluorescent penetrant. Manufacturing personnel assist in fluorescent inspection by blending out defects if they do not lie below parent material thickness.

5.13.2 After the X-ray and fluorescent inspections are completed, inspection clears the sequences in the FAIR book.

5.13.3 The weld land is then Chem-filmed on inboard and outboard sides by personnel certified in manual chemical processing applications. When the Chem-film has dried for a minimum of 12 hours, the weld land area is covered with approved tape. The FAIR book is checked for signoffs on all items.

6.0 CYLINDER 1 TO J JOINT CIRCUMFERENTIAL WELD

6.1 GENERAL DESCRIPTION

6.1.1 The LH₂ tank is joined to the LO₂ tank by a circumferential weld. This weld joins the aft edge of Cylinder 1 to the J-shaped flange of the forward facing sheet of the common bulkhead. This operation is performed after LH₂ Cylinder 1 has been welded to Cylinder 2 and before the girth weld of the LO₂ tank. Because of the inaccessibility of the inboard side of this weld, the tooling and techniques used are unique to this operation.

6.1.2 An audio-visual aid, consisting of 35 mm slides with a tape sound track, has been prepared and is to be used in conjunction with this text for J weld operations.

6.1.3 Reference documents applicable to this procedure are as follows:

MHP-A-48-S-II	Position Common Bulkhead in the Manufacturing Aid
MHP-A-49-S-II	Mate Cylinder 1/2 to the Common Bulkhead
V7-333002	LO ₂ Tank Assembly
V7-332742	LH ₂ Tank Lower Cylinder
V7-333102	LO ₂ Tank Common Bulkhead
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components of Chem-Film
TOS506-0018	Trim Skate - J Weld
TOS556-0039	Support Fixture - LO ₂ Tank Subassembly
971-D-00225	Weld Schedule
PRO565-019	Circumferential weld J on Common Bulkhead to Cylinder 1 and 2 Assembly

6.2 MOVING STATION 1B

6.2.1 This operation is accomplished in Station 1B. This station is a building mounted on a standard station dolly. The building moves with the dolly and the assemblies are moved in and out of the station by removing the roof. The roof is lifted off the station using the 70-ton overhead crane in front of Station 5. The station is moved inside the vertical assembly building so that the overhead crane can be used to move assemblies into the station.

6.2.2 The support tool (T-7200753) is used to support this assembly.



6.2.3 The maintenance department disconnects all utilities from Station 1B, and the riggers move the station under the 70-ton bridge crane in front of Station 5 and remove the roof. Station 1B is then moved into the vertical assembly building by means of the transfer table.

CAUTION

All moves and loading of the stage components are accomplished under the direction of a move conductor. Manufacturing has the responsibility to see that all safety practices are followed to assure against damage to the stage hardware and injury to personnel.

6.3 POSITIONING COMMON BULKHEAD AND CYLINDER 1 - CYLINDER 2 ASSEMBLY

6.3.1 The common bulkhead is loaded onto 12 jig stops on the support fixture (T-7200753) which is permanently located in Station 1B per MHP-A-48-S-II (Figure 6-1).

CAUTION

The jig stops must be set radially so that the bolting boss on the inside of the bulkhead rests on stops. If the stops are rotated out of position, the bulkhead will be damaged during the loading operation.

6.3.2 The hydraulic support jacks are installed on the support tool. The base of each jack is engaged on the bullet-nose pins set in the base of the support tool and the center of the jack is fastened to the tool by means of the jack plate and hand nut.

6.3.3 Two ball lock pins are installed in the top of each jack. One pin rests on the outer shell of the jack to prevent the jack from lowering and the second pin is installed through the slotted hole in the outer shell to prevent the jack from being raised inadvertently (Figure 6-2).

6.3.4 The upper pads on the jacks are set to an equal height or level plane. Measurements are made from the top of the pad to the top of the jack cylinder. The adjustment bolts are screwed in or out to equalize the setting of the pads (Figure 6-3).

6.3.5 The Cylinder 1-Cylinder 2 assembly is loaded onto the jack pads per MHP-A-49-S-II. The bolting ring flange of Cylinder 1 rests on all pads. Any pads which are low are readjusted to the correct height (Figure 6-2).



Figure 6-1. Common Bulkhead Loaded on Jig Stops

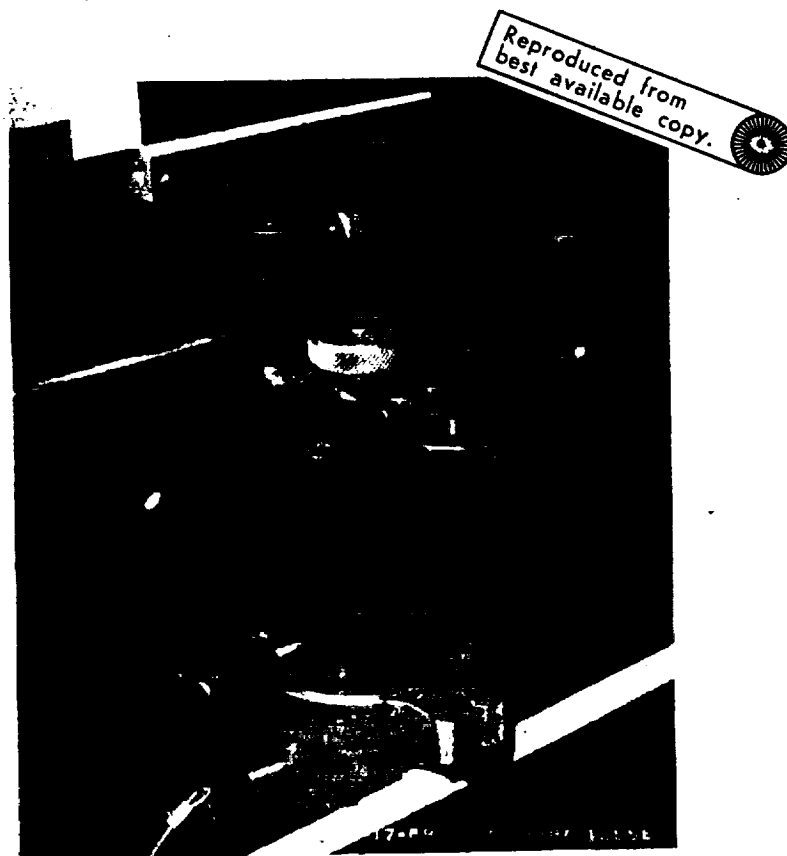


Figure 6-2. Installation of Support Jacks



6.3.6 Safety clamps are installed to clamp the Cylinder 1 flange to the support jacks (Figure 6-4).

CAUTION

These clamps must be installed before moving the station from the vertical assembly building.

6.3.7 The ring pads from the platform (T-7204234) are installed onto the common bulkhead. These pads provide limited access to inboard side of the J area during subsequent operations (Figure 6-5).

6.3.8 Station 1B is moved out of the vertical assembly building to the 70-ton crane in front of Station 5. The roof is reinstalled on Station 1B and the station is moved back into position. Maintenance restores utilities to the station and checks the air conditioning. The station temperature must be a minimum of 76 F and the humidity must not exceed 50 percent.

6.3.9 The tooling department levels the support fixture (T-7200753) and verifies level in the FAIR book (Figure 6-6).

6.4 PREPARATION FOR BULKHEAD TRIM

6.4.1 Two-inch square decals are attached to the common bulkhead at 8 places on the outboard side using the support tool (T-7200753-2901) to establish the height of the decals. The 2-inch decals are placed at the 4 position and 4 fin locations (Figures 6-7 and 6-8).

6.4.2 The bottom edge of the bolting boss (Station XB 284) on the inboard side of the bulkhead is transferred to the decals on the outboard. The stop of the support tool (T-7200753-2901) is placed against the bolting boss and the Station XB 284 plane is marked on the lower decal with a sharp pencil. The upper edge of the tool is marked on the upper decals placed at the J trim line. Inspection verifies the trim reference marks by superimposing the stamps on the trim lines. Inspection also verifies the operation in the FAIR book. See Figures 6-7 and 6-8.

6.4.3 A height gauge is used to measure from the tooling pads on the support tool to the reference marks on the common bulkhead at Station XB 284 at the 8 locations of the 4 fins and 4 position marks. The bulkhead is leveled by adjusting the support pads on the inboard side until the measurements at the 8 locations establish an average level plane within ± 0.030 inch (Figure 6-9).



Figure 6-3. Lock Pins in Support Jacks



Figure 6-4. Safety Clamps on Cylinder

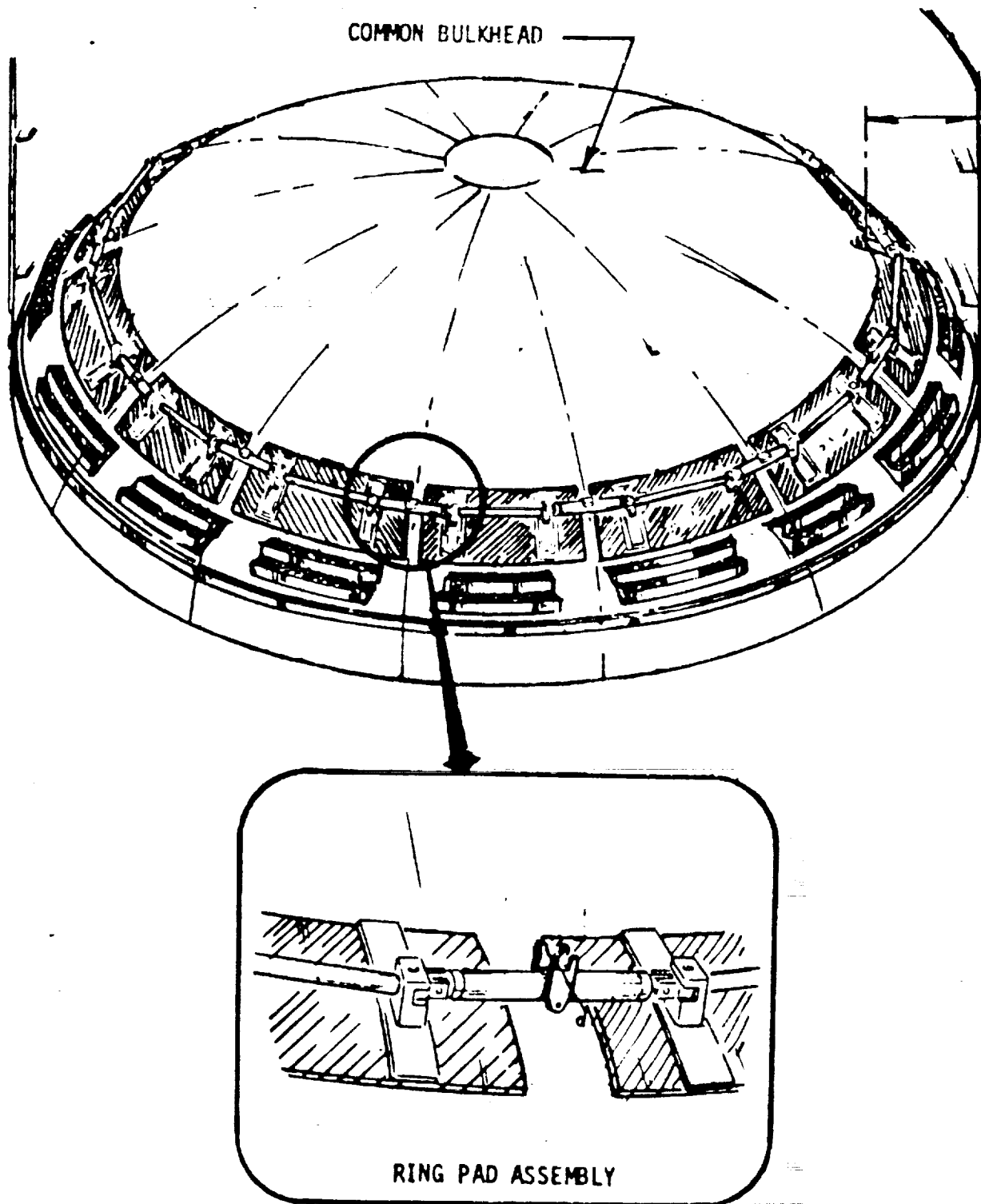


Figure 6-5. Ring Pads on Bulkhead

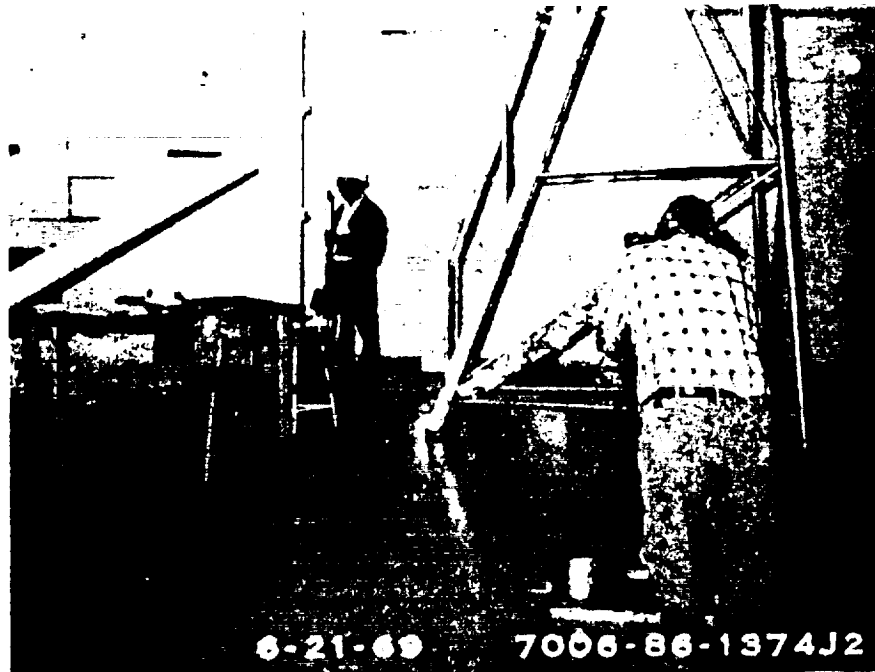


Figure 6-6. Leveling Tool



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Figure 6-7. Positioning Decals for J Trim Reference

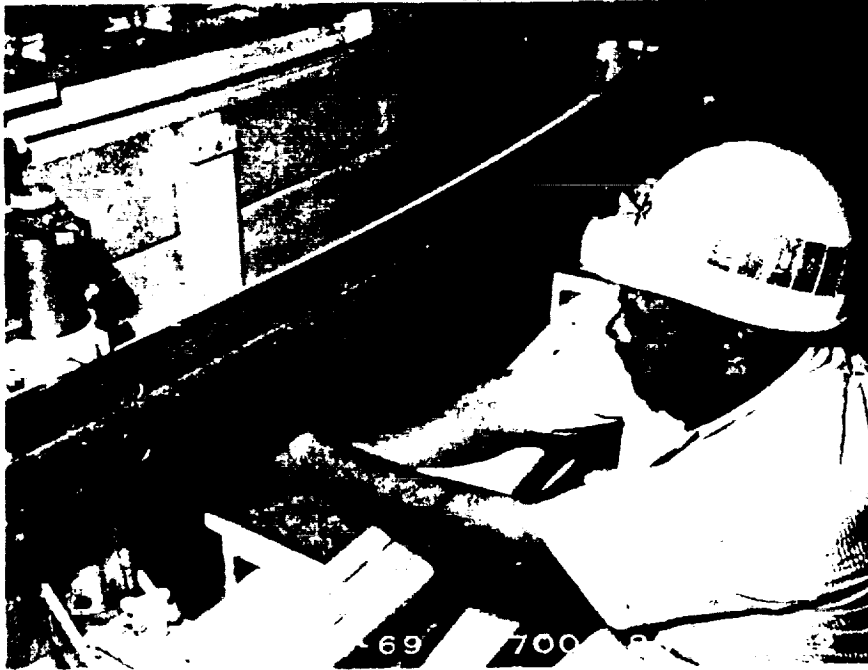


Figure 6-8. Decal Application



Figure 6-9. Use of Height Gauge to Level Common Bulkhead



6.4.4 The level is verified by Inspection and approval is recorded in the FAIR book.

6.5 TRIMMING BULKHEAD

6.5.1 The trim saw is installed on the skate track of the support tool (Figure 6-10). The height of the saw is set so that the lower edge of the blade is on the net trim line previously established at the 8 points.

CAUTION

The saw cut must be above the scribe lines.

6.5.2 The depth stop on the saw is checked and reset if required. The blade must not protrude more than 1/8 inch through the material (Figure 6-11). The clearance between the inboard side of the J tang and the forward face sheet at the trim line is only 3/8 inch.

CAUTION

The depth stop must be firmly locked. Any damaged, missing, or inoperative parts must be replaced before proceeding.

6.5.3 The air to the saw drive motor is turned on. The cross-slide hand crank is used to run the saw blade into the material to a depth of 0.010 inch, and a check is made that this mark corresponds to the net trim line. This procedure is performed at the eight places around the circumference. If the marks are within ± 0.030 inch, the trim is made. If they are not within ± 0.030 inch the level of the bulkhead is rechecked and adjustment made (Figure 6-10).

6.5.4 The carriage drive motor is engaged with the gear rack on the skate track.

6.5.5 The air to the trim saw motor is turned on. The hand crank is used to run the saw through the material until the preset stop bottoms on the material. The valve to the carriage drive motor is opened and the speed of the carriage regulated by means of a small regulator on the carriage. The feed should be as fast as can be attained without slowing down the saw motor (Figure 6-10).

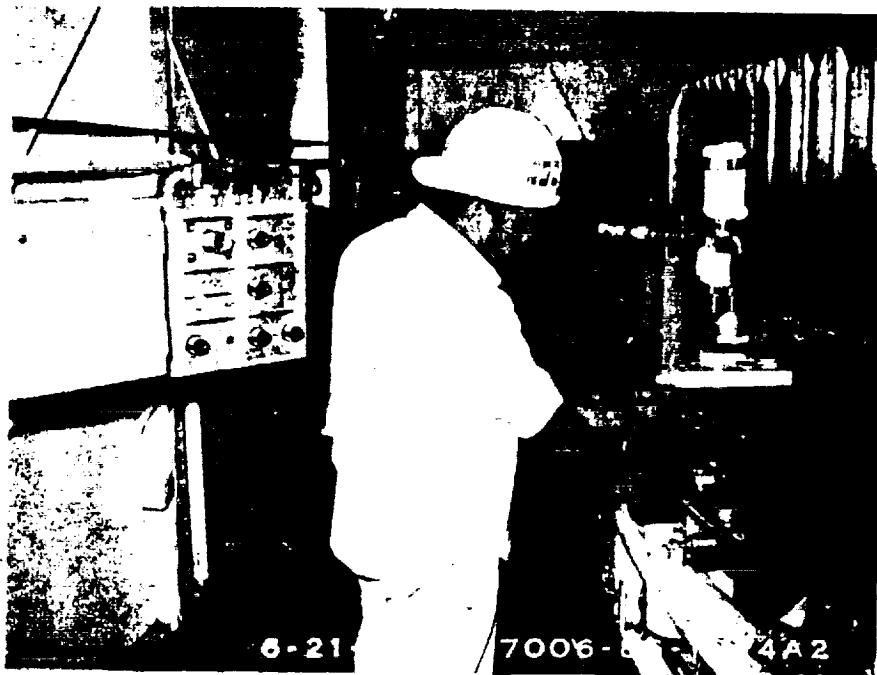


Figure 6-10. Installation of Trim Saw



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Figure 6-11. Depth Stop on Saw



6.5.6 Shims of 0.150-inch dimension are inserted behind the saw blade to prevent the scrap material from binding the blade and producing a rough cut.

6.5.7 The top ball lock pin must be pulled out of each jack support ahead of the saw. The control valve of the individual jack is turned to retract position, and the jack is lowered. After the saw passes, the jack is raised and the ball lock pin inserted again (Figures 6-3 and 6-11).

CAUTION

One jack at a time is lowered ahead of the saw. The jack behind the saw must be raised before lowering the next one. Only qualified personnel operate the hydraulic panel for the jack system.

6.5.8 The trimmed scrap material is removed, and the chips are vacuumed from the tooling, floor, and assembly.

6.5.9 Trim is verified by Inspection approval in the FAIR book.

6.6 PREPARATION FOR CYLINDER TRIM

6.6.1 Eight decals are attached to the cylinder approximately 1 inch below the bolt flange at the 4 fins and the 4 positions (Figure 6-12).

6.6.2 The trim line on Cylinder 1 is established by means of the gauge blocks (T-7200753-1347). The gauge is clamped to the flange on Cylinder 1. The trim is marked on the eight decals (Figure 6-12).

6.6.3 The detail (T-7200753-TDV-83609) is used as a height gauge to level Cylinder 1. The guage is placed on the leveling pads of the T-7200753 tool and a 0.010-inch feeler guage is used between the guage and the cylinder flange to bring the cylinder into a plane (Figure 6-13). Level is checked at the 8 locations. The screws on the pads on top of the support jacks are used to raise or lower the cylinder (Figures 6-2 and 6-3).

6.7 TRIMMING CYLINDER

6.7.1 The trim saw is adjusted for height; the upper edge of the blade must be on the net trim line.



Figure 6-12. Decal for Cylinder 1 Trim

CAUTION

The saw cut must be below the scribe line.

6.7.2 The depth stop on the saw is checked to make sure the bolts have not loosened or the stop has not changed since the previous trim.

6.7.3 The cylinder is marked, checked, and trimmed following Steps 6.5.3 to 6.6.7 (Figure 6-10).

6.7.4 The trimmed scrap material is removed and the chips vacuumed from the area.

6.7.5 The trim dimensions from Station XB 284 to Station B 299.380 are verified at 8 places and entered in the FAIR book (Figure 6-9).

6.8 PREPARING FOR WELD

6.8.1 Pi-tape readings of Cylinder 1 and the J section are taken at the trim line using techniques described in Section 1.15. The readings are logged in the FAIR book.

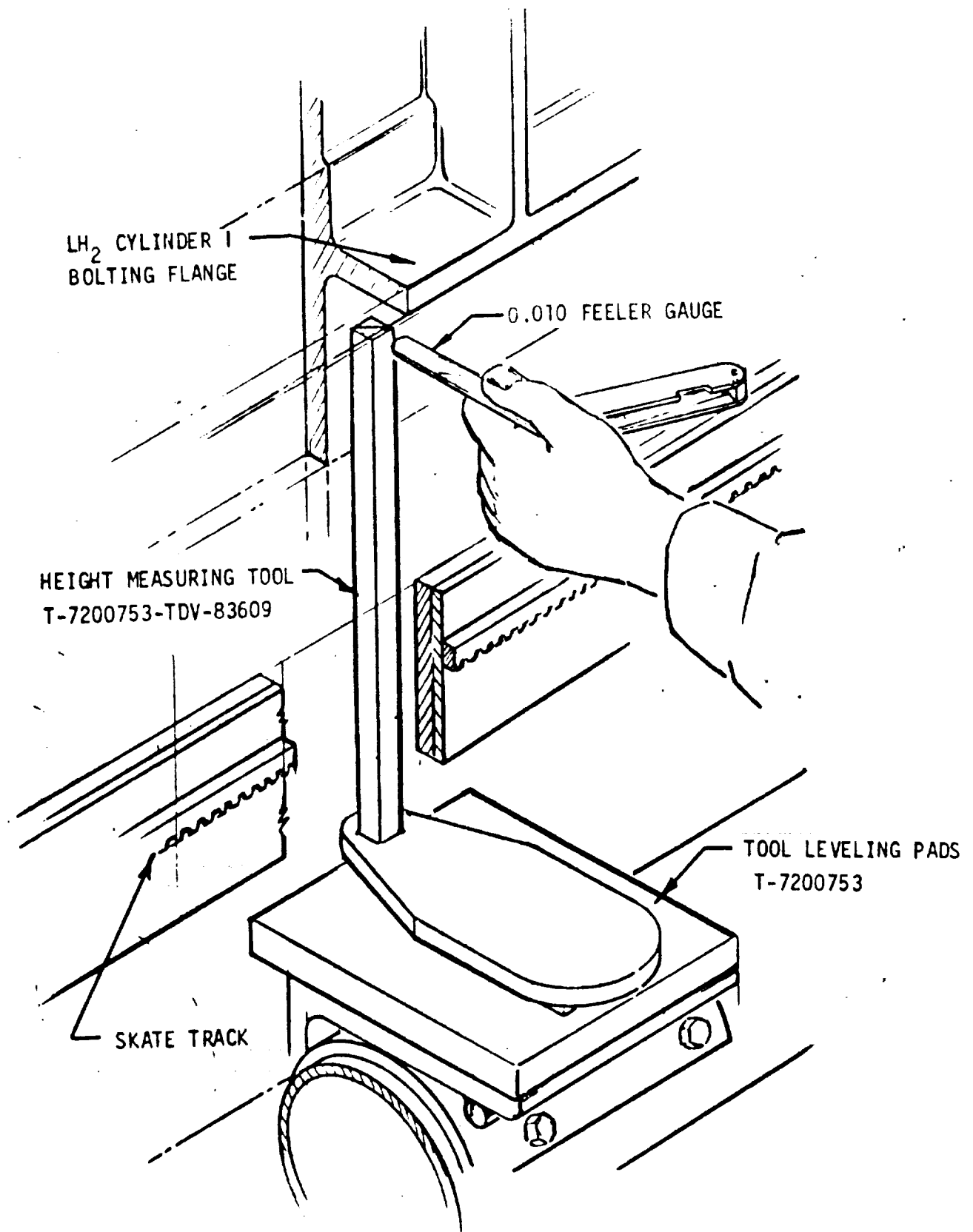


Figure 6-13. Use of Height Gauge



- 6.8.2 Premarked measuring tape is applied around the circumference of the J section. The tape is marked at 3-inch intervals from zero to 1244 inches. The zero-inch mark must be at Position 1 (Figure 6-14).
- 6.8.3 Inspection takes material thickness readings on Cylinder 1 and the J section and logs the dimensions on an ITI sheet.
- 6.8.4 The dust is wiped from the common bulkhead with cheesecloth. A debris barrier is installed below the pads on the common bulkhead to prevent dirt from falling into the J-section area during precleaning operations (Figure 6-15).
- 6.8.5 The trim line is marked for the tang of the J using a shop aid tool. The tool rides the bottom of the J on the inboard side, projecting over the top of the J, and marks the trim line on the outboard side (Figure 6-16).
- 6.8.6 All control handles on the support jack system are checked; they must be in the neutral or off positions (Figure 6-17). Installation of all safety clamps fastening Cylinder 1 to the support jacks is verified (Figure 6-4). All of the lower ball lock pins are pulled from the support jacks (Figure 6-8).

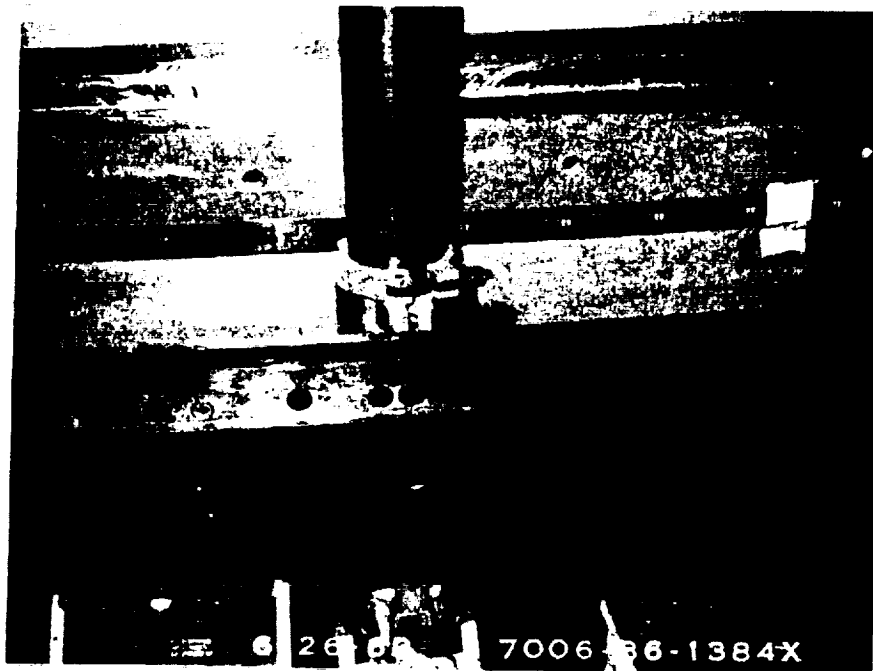


Figure 6-14. Application of Marked Tape

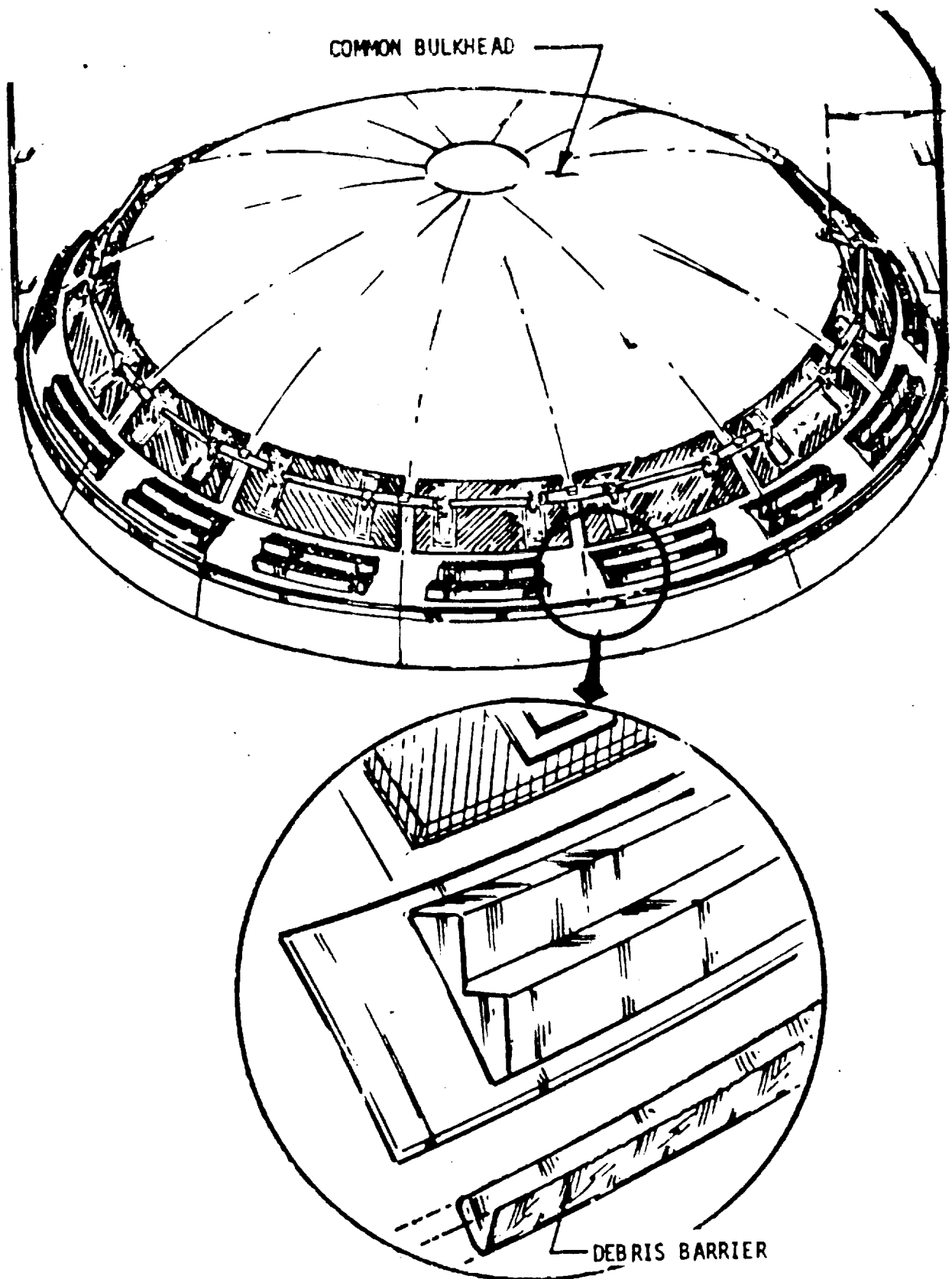
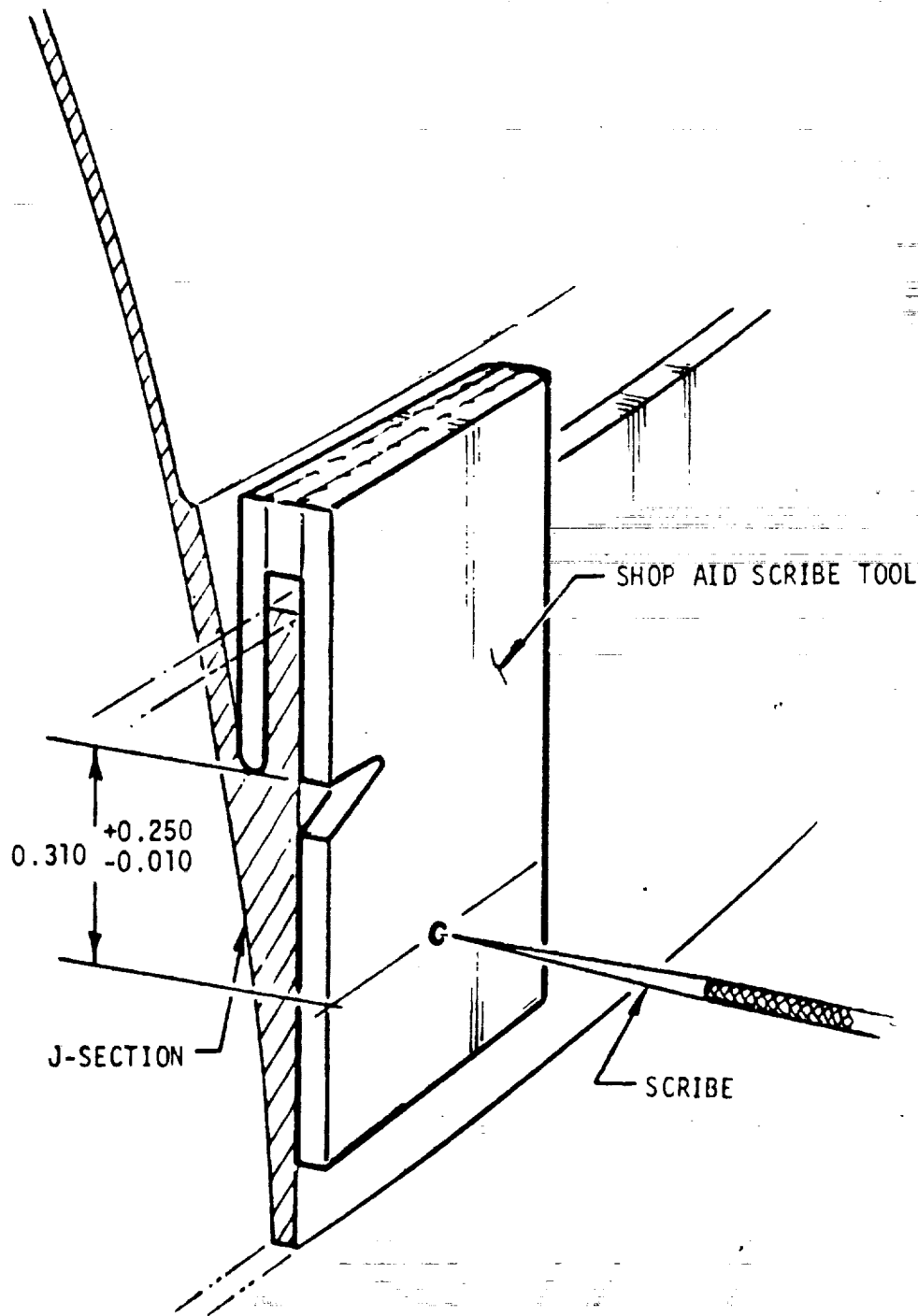


Figure 6-15. Debris Barrier Below Ring Pads



MARKING J TANG TRIM

Figure 6-16. Trim Line for J Section Tang



6.8.7 Using the hydraulic control panel, the Cylinder 1-Cylinder 2 assembly is raised approximately 15 inches (Figure 6-18).

CAUTION

Only trained personnel are to operate the hydraulic control panel.

6.8.8 The safety clamps (T-7200753-2509) are installed on the support jacks and all control valves turned off (Figures 6-14 and 6-17).

6.9 VERIFICATION PANELS

6.9.1 These panels are made prior to preweld cleaning as described in Section 1.14.

6.10 PREWELD CLEANING

6.10.1 Preweld cleaning of the joint follows the procedures described in Section 1.12. All precleaning operations must be accomplished from the outboard side. The inside of the J is cleaned with special vixen files (Figure 6-19).

CAUTION

Extreme care must be exercised to prevent scratches on the inboard side of the joint. The files must be held flat on the inboard surface so that the edge of the file does not gouge the material.

6.10.2 A mirror is used to check the back side of the joint for cleanliness. The area is vacuum-cleaned of all chips. Cleaned surfaces must not be touched. The joint is visually checked for nicks, scratches, and contamination.

6.10.3 The white lights in the station are turned out and a blacklight inspection is made of the cleaned surfaces. Any material which fluoresces is removed.

6.10.4 The safety clamps are removed from the support jacks. The assembly is lowered by opening all the control valves on the jacks and then bleeding the valves on the console.

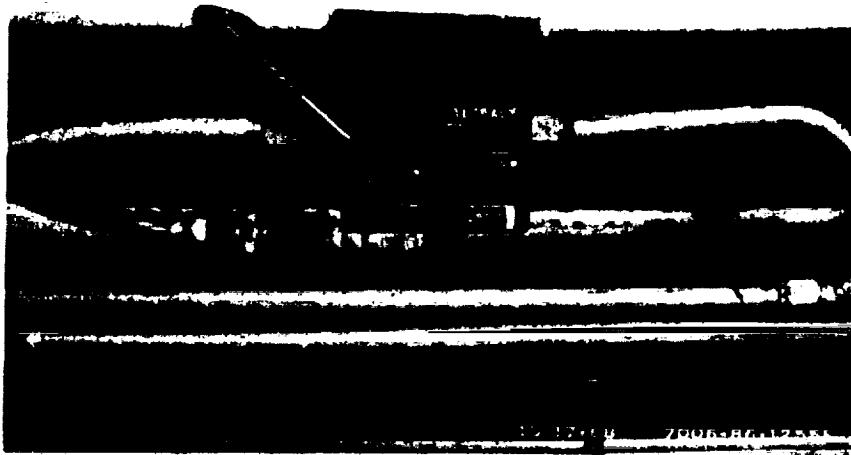


Figure 6-17. Control Handles of Support Jack System

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Figure 6-18. Cylinders Raised 15 Inches for Cleaning



Figure 6-19. Special Vixen File Used Inside J Section

CAUTION

Only qualified personnel may operate the hydraulic console.

6.10.5 A 1/2-inch gap is maintained between the butt faces of Cylinder 1 and the J-joint. If the assembly is to be idle between shifts, the joint is covered on the outboard side with aluminum foil.

6.10.6 One-half of the support pads on the top of the support jacks are changed to roller-type pads. The fixed- and roller-type pads are alternated. The roller pads allow the assembly to be rotated for alignment purposes prior to welding (Figure 6-20).

6.10.7 All chips are vacuum-cleaned from the station. The environment limitations (station humidity of 50 percent maximum and temperature of 76 F minimum) are verified.

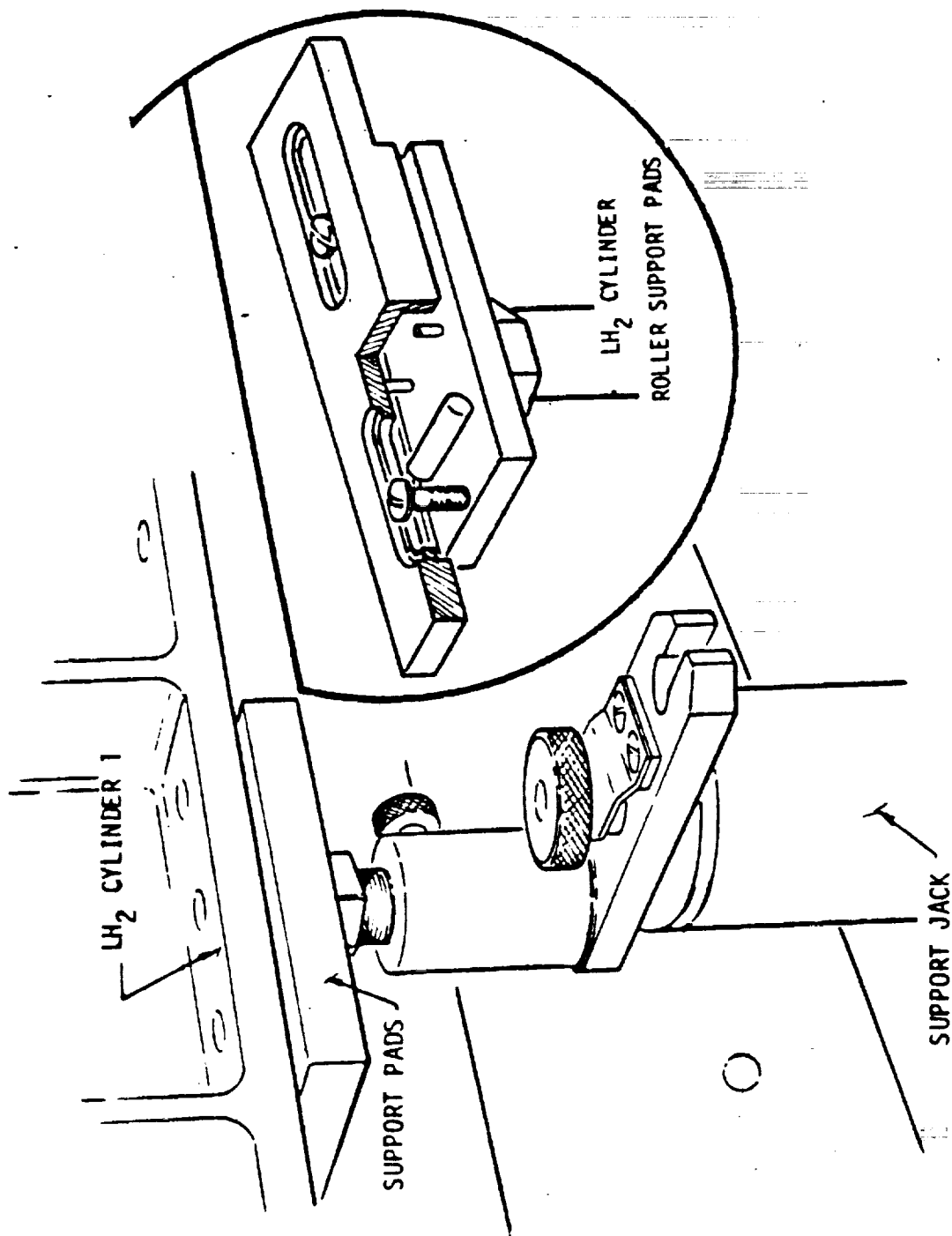


Figure 6-20. Roller Pads on Jacks for Rotation Alignment

CAUTION

Temperature and humidity allowables must be maintained.
If conditions cannot be maintained, contact Maintenance.

6.10.8 Aluminum foil is removed and the weld joint is given final cleaning, following procedures described in Section 1.12.

6.10.9 Blacklight inspection is made of the weld joint and any material that fluoresces is removed (Figure 6-21).

6.11 CYLINDER LOWERING AND ASSEMBLY ALIGNMENT

6.11.1 Cylinder 1 is lowered by means of the screws on the pads of the support jacks. The assembly is lowered until a gap of 0.040 inch exists between the butt faces of Cylinder 1 and the J joint (Figure 6-2).

6.11.2 The position alignment tool (T-7205017) is installed onto the skate track. The tool is leveled using the built-in spirit level and adjusting the screws. The vertical bar of the tool is lined up with the Position I mark on the common bulkhead using a tooling bar. The tooling bar is projected



Figure 6-21. Blacklight Inspection



from the upper pad on the vertical bar to the Position I mark on Cylinder 1. The position marks must line up with 0.030 inch. If they do not line up Cylinder 1 is rotated to position (Figure 6-22).

6.11.3 The alignment clamps (T-7203536) are installed around the circumference; these pin into Cylinder 1 with pins through the flange and by using a screw adjustment on the pressure pads. The joint is aligned by pushing in on the J and pulling out on the Cylinder 1 (Figure 6-23).

6.11.4 The alignment bars (T-7204084) are bolted into existing holes in the J tang and by means of a screw adjustment they push Cylinder 1 in while pulling out on the J (see Figure 6-24).

6.11.5 Control of the offset is maintained by alternating the bars and clamps.

CAUTION

Constant monitoring of the alignment tools must be maintained during the tack-welding operation to control offset as conditions change with each tack weld.

6.11.6 Inspection verifies the rotational alignment and the FAIR book is cleared.

6.12 WELDING OPERATIONS

6.12.1 During the lowering and rotational alignment checks on Cylinder 1, the welders verify their machines by running a bead-on plate and installing the weld heads on the skate track. The welders install the ground and sensing leads and these are verified by the weld engineers.

CAUTION

The ground cable must make direct contact with the J tang.

6.12.2 The offset at Position I is checked. The alignment clamps are adjusted to maintain an offset of 0.005 to 0.010 inch between Cylinder 1 and the J. The J must be on the minus side (inboard of the cylinder) because it will move outboard during subsequent welding.

6.12.3 The weld machines are programmed with the parameters for the intermittent tack weld, per the 971-D-00225 Weld Schedule.

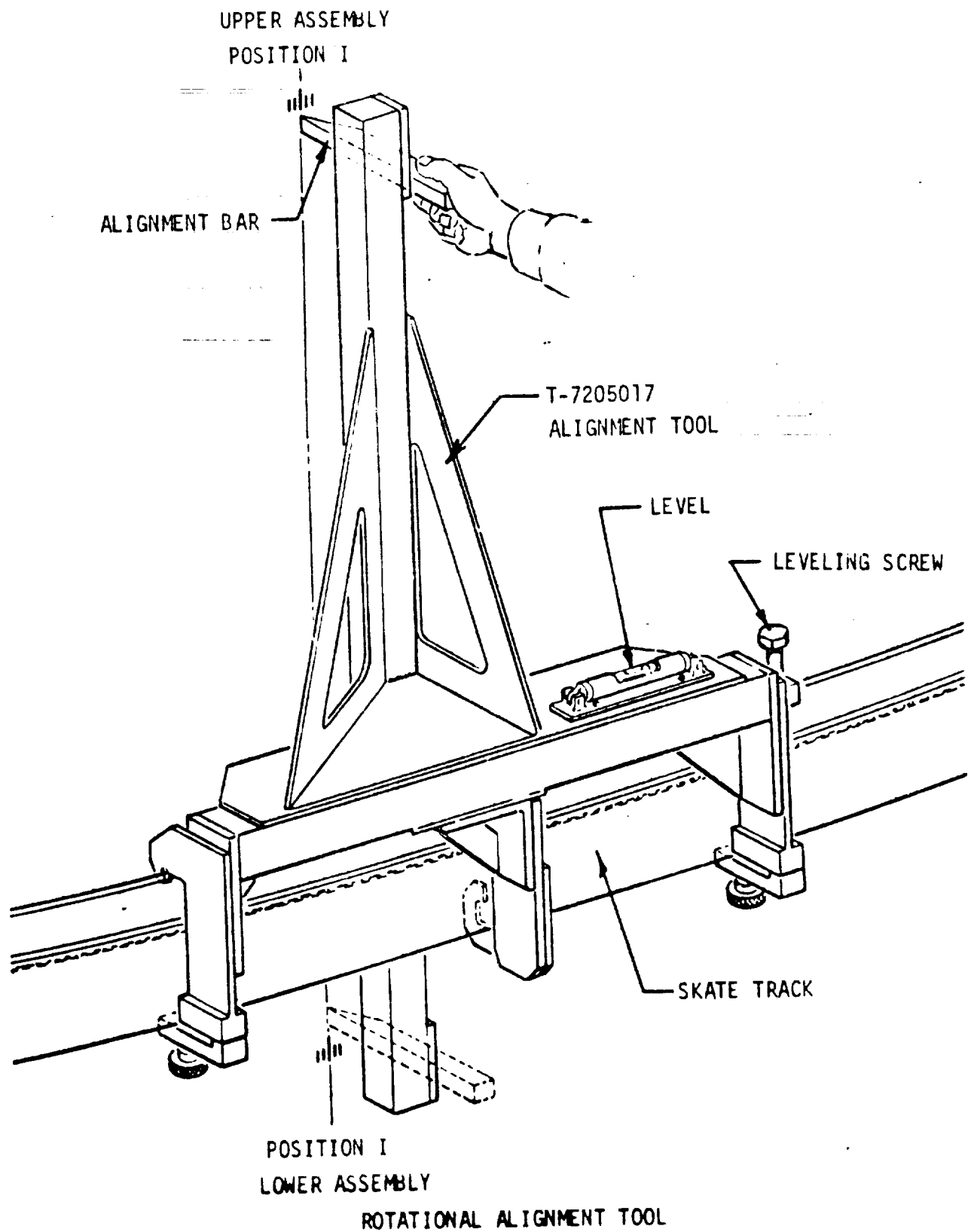


Figure 6-22. Rotational Alignment Tool

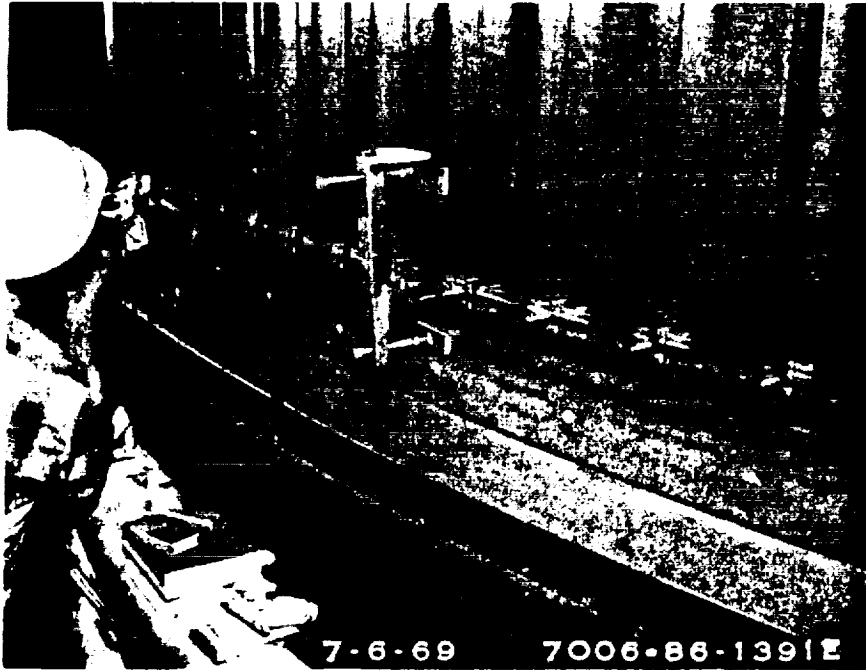


Figure 6-23. Alignment Clamps — Push



Figure 6-24. Alignment Clamps — Pull



6.12.4 A minimum of 3 or a maximum of 6 tacks are run at Position I. The tacks are 3 inches long on 9-inch centers (Figure 6-25).

6.12.5 After these alignment tack-welds are made, the gap and offset are rechecked and adjusted around the circumference. The offset in the rough state must not exceed 0.020 inch. The gap may exceed 0.040 inch except at the point of tacking.

6.12.6 The gap can be adjusted by using the control jacks (T-7204833). The control jacks tie into predrilled holes in the J tang and by means of an adjustment screw, Cylinder 1 is raised. Maintaining a slight gap allows the offset adjustment without scrubbing the butt faces, which causes weld defects.

6.12.7 Tacking operations are started at Position I and Position III (approximately). Alignment adjustment is made at each tack. The joint must be vacuum-cleaned just before tacking.

CAUTION

Do not touch joint with vacuum hose.

6.12.8 Tacks are made progressively around the circumference of the assembly. The offset is checked ahead of the tack area and adjusted to maintain the offset within established limits. Inspection measures the offset at each tack as it is welded and logs the offset on an ITI sheet. The remaining support tooling is removed at this time.

6.12.9 The continuous tack weld is run. A man is stationed at each machine to handle the weld cables which must be moved around the assembly as the weld head moves on the track. Two weld heads are used, starting 180 degrees apart, with the welds overlapping a minimum of 6 inches. An air motor with a ball rotary file is used to grind out the tailout crater as each machine sequences out to prevent cracks from propagating. The crater is ground out to a maximum of 0.060 inch using a ball rotary file (Figure 6-26).

6.12.10 A stainless steel rotary or hand brush is used to wire brush the entire weld. Brush in long strokes in one direction only.

CAUTION

Do not touch the cleaned surface.

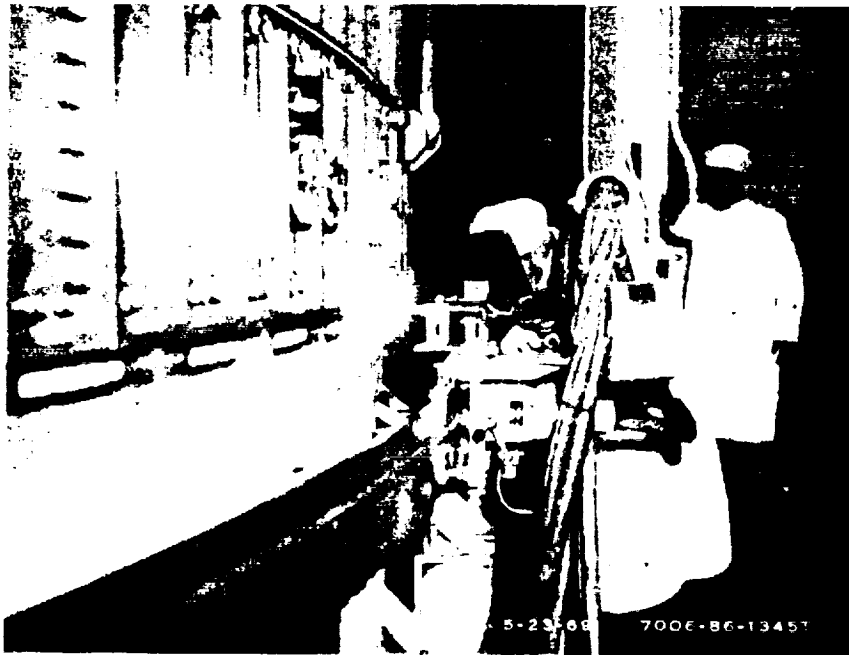


Figure 6-25. Intermittent Tack Welding

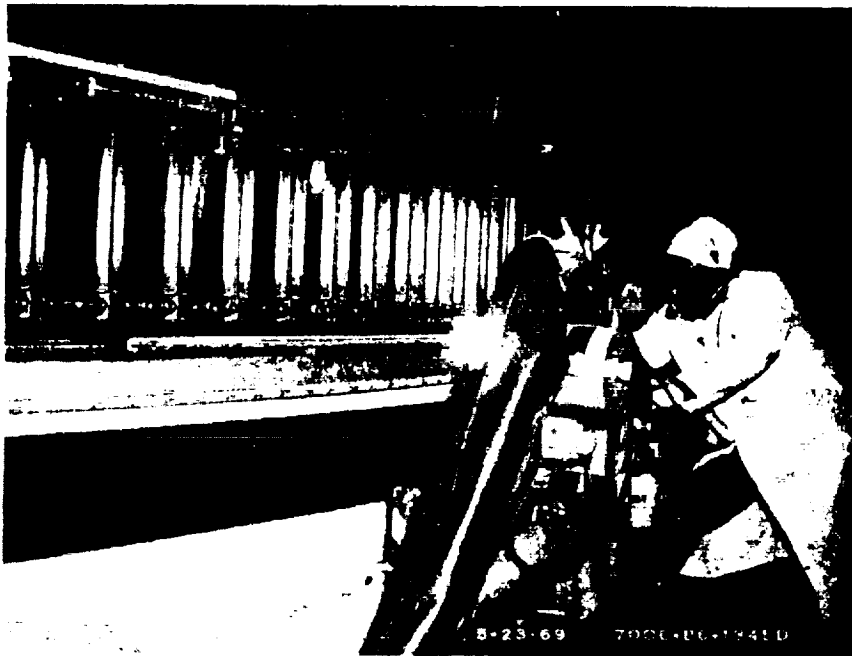


Figure 6-26. Continuous Tack Welding



6.12.11 The welders change the machine settings per the 971-D-00225 Weld Schedule for the penetration pass during the wire-brush operation. The inspector verifies the machine setting. The override control boxes are moved to the inboard side of Cylinder 1, turned on, and the penetration pass is made.

6.12.12 The two weld heads are used 180 degrees apart. The drop-through is monitored from the inside. The cable tending, overlap of weld, and the grinding out of tailout crater are performed following the same procedures as described for the continuous tack pass.

6.12.13 A stainless steel rotary or hand brush is used to brush the entire weld. Long strokes are used in one direction only.

6.12.14 The penetration pass is inspected for incomplete penetration. Any areas of incomplete penetration are picked up per the 971-D-00225 Weld Schedule.

6.12.15 The penetration pass is X-rayed.

6.12.16 Manufacturing supervision reviews defective areas to determine if rework is required before the cover passes are made. If rework is required, the standards described in Section 10 are followed.

6.12.17 The penetration pass is brushed with clean stainless steel brushes prior to making the cover pass. Brush strokes are made in one direction only.

6.12.18 During the wire brushing, the welders program the weld machines per the 971-D-00225 Weld Schedule and verify the machines for cover pass. Inspection checks the machine settings.

6.12.19 The cover passes are run. The cable tenders handle the cables (Figure 6-26). The tailout crater is ground out to a depth of 0.060 inch with a ball rotary file. The entire weld is brushed using a stainless steel rotary brush.

6.12.20 Visual inspection is made of the weld for lack of fill. Supplementary weld passes are made on any areas which are out of specification.

6.13 POST-WELD OPERATIONS

6.13.1 The cover pass is milled with weld shavers to 0.010 inch from the parent material. The milling is performed on the outboard side only.



CAUTION

Parent material must not be gouged.

- 6.13.2 The outboard weld bead is abraded with a Bear-Text rotary wheel using a long stroke. The Bear-Text wheel is mounted with the arrow pointing in the direction of rotation. Bear-Text abrading must not be made at an angle to the weld direction.
- 6.13.3 X-ray personnel x-ray the entire weld and read the film. Triangulation shots are made if any areas are out of specification. Rework of the areas may be by in-process rework or MR action (See Section 10).
- 6.13.4 After X-ray is complete, the weld is inspected with fluorescent penetrant on the outboard side. Any defects which do not lie below parent material are blended out with a Bear-Text wheel.
- 6.13.5 When the X-ray and penetrant inspection are completed, Inspection records the item in the FAIR book.
- 6.13.6 Chem-film is applied to the weld area on the inboard and outboard sides. Qualified personnel only are to apply Chem-film. When the Chem-film has dried, the inboard side of the J is painted by the processing department.
- 6.13.7 The FAIR book is checked and all entries cleared.
- 6.14 TRIM J TANG
- 6.14.1 The trim of the J tang is laid out per the drawing dimensions. The trim is marked at the end and center of each bulkhead gore (Figure 6-16).
- 6.14.2 The trim saw is installed on the skate track and the depth stop on the saw set so that it just breaks through the back side of the tang (Figure 6-27).

CAUTION

The clearance between the tang and the bulkhead varies. Extreme care must be exercised to prevent damage to the bulkhead.



Figure 6-27. Depth Stop on Tang Trim

6.14.3 The saw is tracked around the circumference at each of the trim reference points, and the saw height is set to the lowest mark. The top edge of the blade is used for checking (Figure 6-16).

CAUTION

The saw cut must be below the scribe lines.

6.14.4 The saw motor is turned on and, using the cross-feed slide, the blade is run into the tang in increments. The depth is checked at each increment as a check on the setting of the depth stop.

6.14.5 The entire tang is trimmed while constantly monitoring the depth of the cut.

CAUTION

The saw and the clearance between the tang and the bulkhead is checked continuously to prevent accidental saw marks on the bulkhead.



6.14.6 The trim scrap is removed and all chips are vacuum-cleaned from the area.

6.14.7 With vixen files held flat on the trim edge, the tang is draw-filed to remove the saw marks. A stainless steel shield may be used to protect the bulkhead. The sharp edge is broken with the file (Figure 6-28).

CAUTION

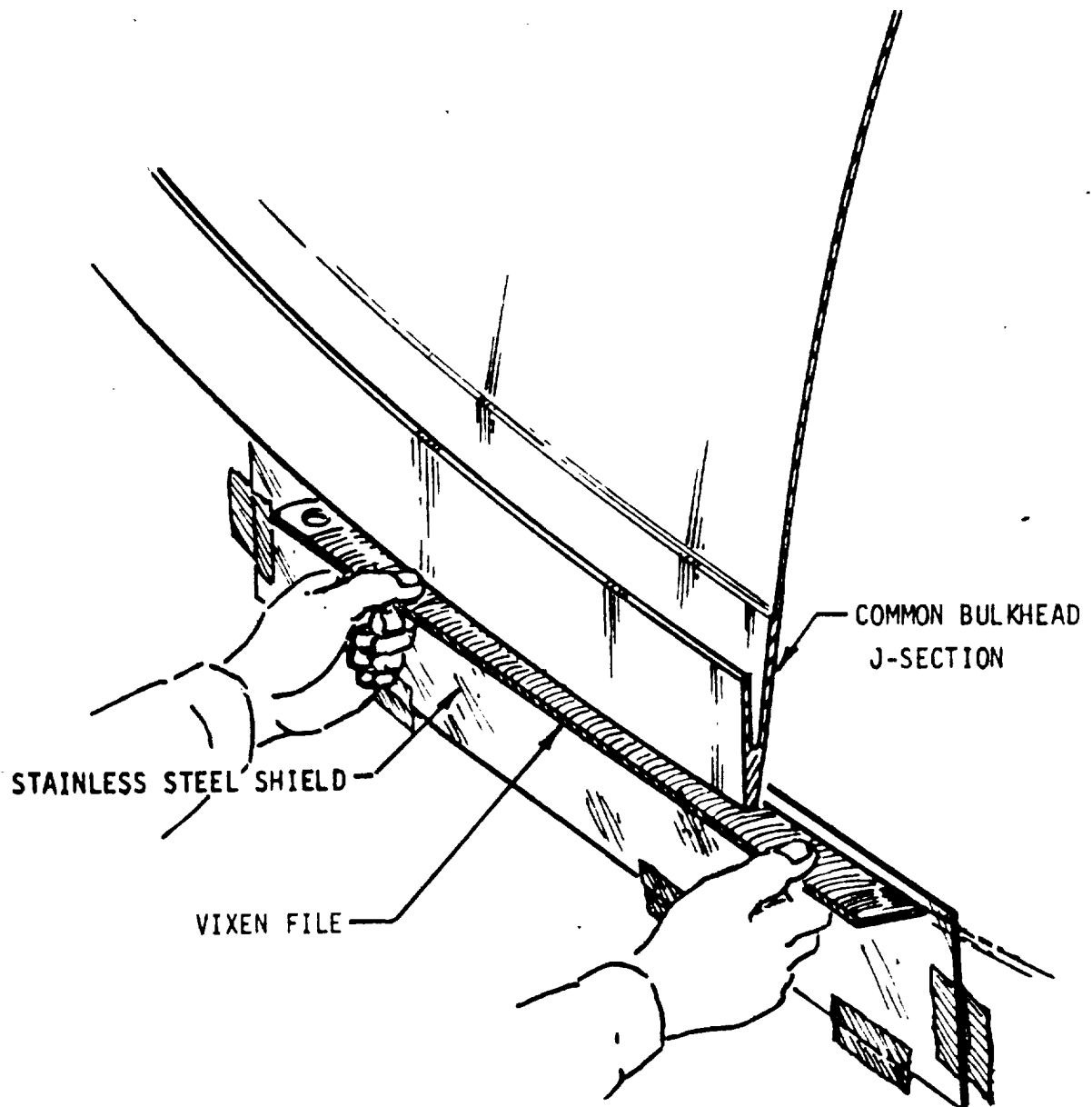
The bulkhead must not be scratched or gouged.

6.14.8 The trim edge of the tang is polished with a Bear-Text wheel. A stainless steel shield is used between the tang and the bulkhead.

6.14.9 The tang trim is Chem-filmed. Qualified personnel only are to apply Chem-film.

6.14.10 All items are cleared in the FAIR book.

6.14.11 The assembly is turned over to structures group for bolting ring installation.



DRAW FILE SAWED EDGE OF J-TANG

Figure 6-28. Filing Tang Trim



1. The first part of the document is a list of items, each with a number and a description.

2. The second part of the document is a table with two columns and three rows.

3. The third part of the document is a list of items, each with a number and a description.

4. The fourth part of the document is a list of items, each with a number and a description.

5. The fifth part of the document is a list of items, each with a number and a description.

6. The sixth part of the document is a list of items, each with a number and a description.

7. The seventh part of the document is a list of items, each with a number and a description.

8. The eighth part of the document is a list of items, each with a number and a description.

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10.



7.0 CYLINDER 6 TO CYLINDER 5 CIRCUMFERENTIAL WELD

7.1 GENERAL DESCRIPTION

7.1.1 This section defines the techniques and procedures utilized in the circumferential weld joining of Cylinder 5 to Cylinder 6 of the LH₂ tank. This welding operation is performed in Station 1. The Cylinder 3-4-5 assembly is located on the support tool (T-7200516) and internal access is by the tool's work platform. The Cylinder 6-LH₂ bulkhead assembly is joined to the Cylinder 3-4-5 assembly by a circumferential weld. The weld joint offset is controlled by an internal circumferential sizing tool (T-7204464). This section includes a description of the detailed procedures essential to successful welding of this joint.

7.1.2 Reference documents applicable to this procedure are as follows:

V7-332002	LH ₂ Tank Assembly
V7-332242	LH ₂ Tank Upper Cylinder Assembly (No. 6)
V7-332342	LH ₂ Tank Upper Intermediate Cylinder Assembly (No. 5)
V7-332442	LH ₂ Tank Upper Center Cylinder Assembly (No. 4)
V7-332542	LH ₂ Tank Lower Center Cylinder Assembly (No. 3)
V7-312142	LH ₂ Bulkhead
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-Film
971-D-00265	Weld Schedule
MHP-A-07-S-II	Position LH ₂ Stack Assembly (3/4/5) onto Tool Fixture T-7200516, VAB
MHP-A-08-S-II	Position LH ₂ Bulkhead-Cylinder 6 Assembly on Cylinder 3/4/5 Assembly on Tool Fixture (T-7200516)
TOS-556-008	Turntable Circumferential Weld
TOS-556-0027	Offset Measuring Tool - Circumferential Welding

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7.2 POSITIONING CYLINDER 3-4-5 ASSEMBLY

7.2.1 The riggers position the support tool (T-7200516) in Station 1. The second through the sixth floors in the station must be raised to permit entry of the tool. After the tool is in position, the second and third floors are lowered and the first- and second-floor curtains are closed.

7.2.2 The floor boards on the internal platform of the support tool are retracted, and the lower vacuum chucks of the circumferential sizing tool are loaded on the upper floor of the internal platform.

7.2.3 The Cylinder 3-4-5 assembly is positioned on the support tool.

CAUTION

This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has a responsibility to assure adherence to safety practices. The move conductor must be in attendance during all phases of the move.

7.2.4 The cylinder assembly is moved into the building using the transfer table. The cylinder is loaded on the tool over the internal platform using the overhead crane. The detailed move procedures are covered in the MHP-A-03-S-II. The lower edge of the cylinder is positioned on the 10 supports of the tool. Position I of the cylinder is rotated to match Position I of the tool.

7.2.5 The distance from the tank wall to the third floor is checked at Positions II and IV. The support tool, mounted on the station stage dolly, is moved to equalize the distance.

7.2.6 The tool is leveled by adjusting the leveling jacks on the stage dolly. Tooling personnel perform this operation using sight level to a white-faced scale, referenced to the 4 leveling pins on the tool.

7.2.7 The floor boards are extended back into position on the top floor of the internal platform.

7.2.8 Power and air lines are connected to the support tool. The safety-encapsulated fluorescent lamps are hung on the inboard hand rails (Figure 7-1).



7.2.9 The contoured debris barrier (eyebrows) on the third floor are installed around the cylinder, starting at Position I as marked on both the floor and the eyebrows (Figure 7-2).

7.3 STATION PREPARATION AND TOOLING INSTALLATION

7.3.1 The hydraulic manifold is laid on the upper floor of the internal platform and attached to the hydraulic pump (Figure 7-3). The vacuum cups of the outboard skate track (T-7200039) are wiped with an acetone-dampened cheesecloth. The skate track is installed using the hangers to hold the track parallel to the cylinder edge. Vacuum must not be applied. The sections of the track are joined using a hex wrench in the screws (Figures 7-4 and 7-5).

7.3.2 The set screws are installed in the track and tightened to move the vacuum chuck brackets approximately 1/4-inch inboard. This is done to maintain a near-equal distance from the track to the cylinder wall (Figure 7-6).

7.3.3 Vacuum is applied to hold the track in place by connecting the vacuum lines all around (Figure 7-7). The chucks are tapped lightly to help seat them and prevent vacuum leaks. The hangers and set screws are removed.

7.3.4 Leveling of the skate track is verified using a hanger block as a gauge. The skate track must be parallel to the top edge of the cylinder within ± 0.030 inch. Minor adjustments can be made with a shot-loaded plastic-tipped mallet.

7.3.5 The sheet metal chip catchers are laid on the web of the top frame of Cylinder 5. Aluminum tape is used to seal the edges and joints (Figure 7-8).

7.3.6 A vinyl sheet is laid from the internal platform to the top frame around the entire tank, using tape to hold securely.

7.3.7 Two-inch lengths of Mylar tape are attached horizontally around the circumference on the inboard side. The bottom edge of the tape is positioned 8 inches below the butt edge of Cylinder 5. Three pieces of tape are placed on each quarter-panel 1 foot from each vertical splice weld, left and right; and one piece of tape is placed in the center of the panel. These tape markers are used to position the lower vacuum support chucks.



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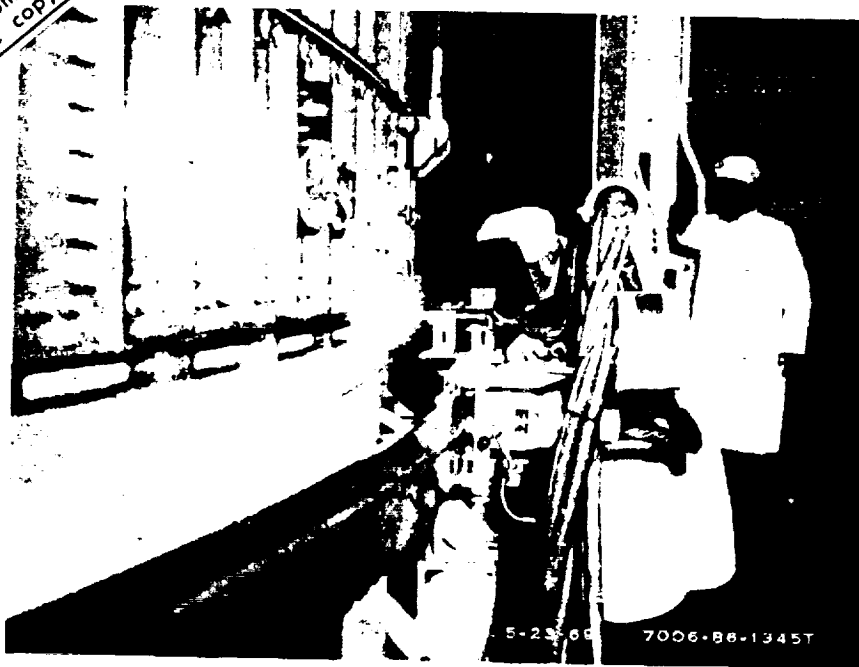


Figure 7-1. Encapsulated Fluorescent Lamp Installation

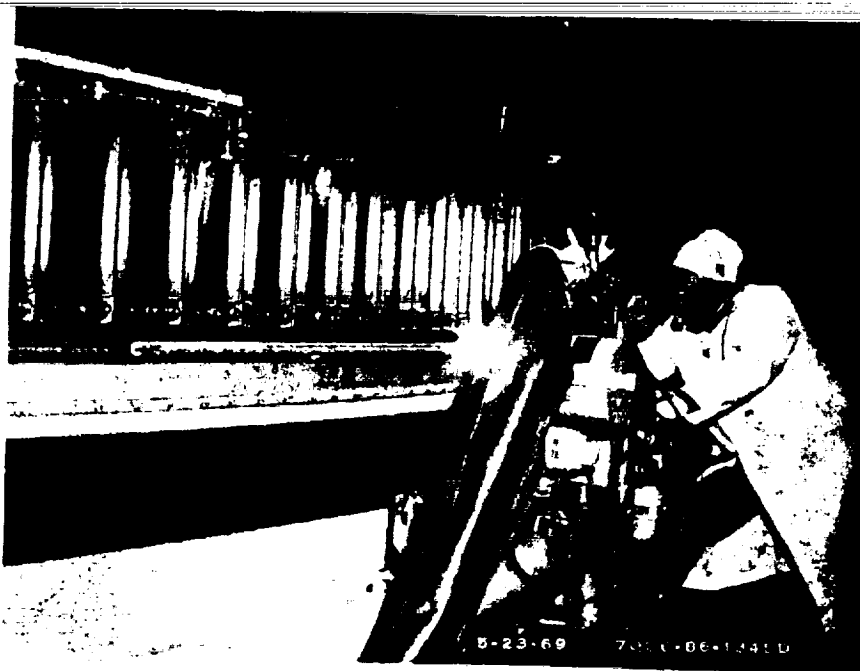


Figure 7-2. Eyebrow Installation and Vacuum Lines

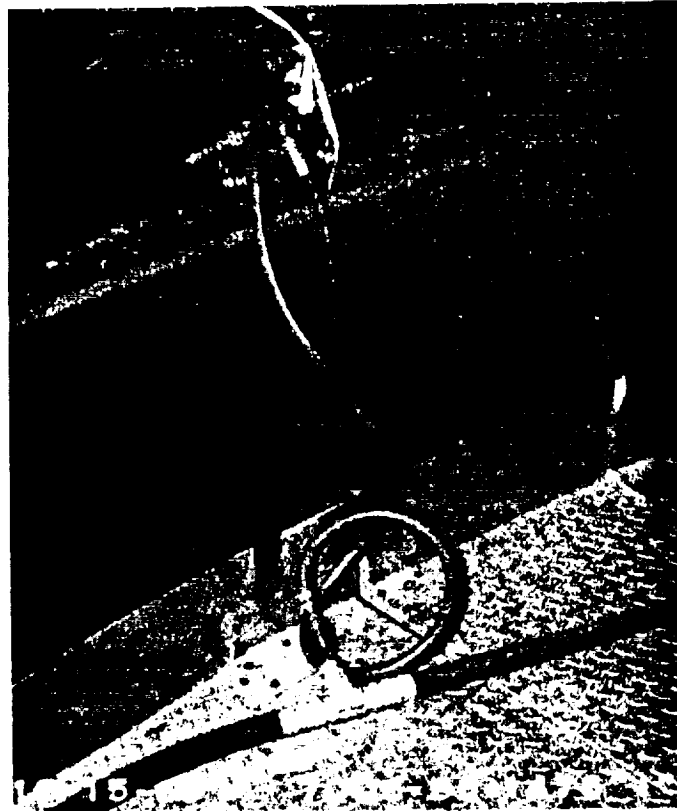


Figure 7-3. Vacuum and Hydraulic Line Installation

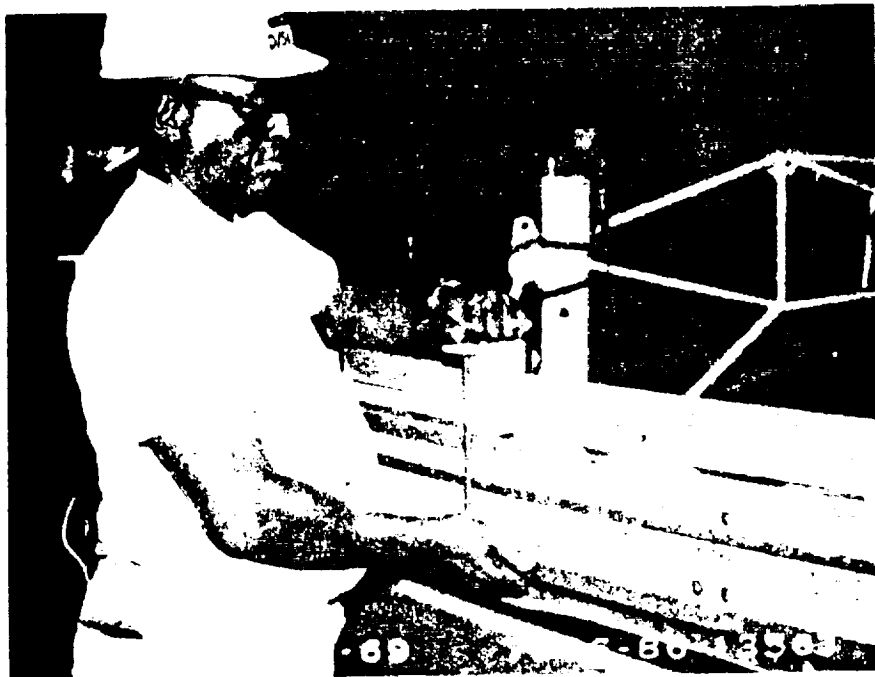


Figure 7-4. Skate Track Hangers Installed

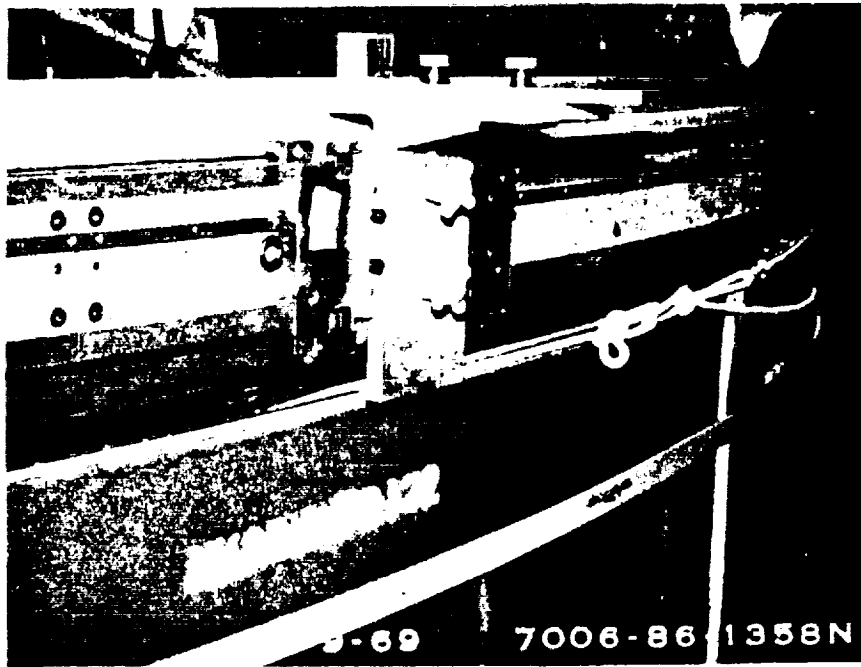


Figure 7-5. Skate Track Section Joint

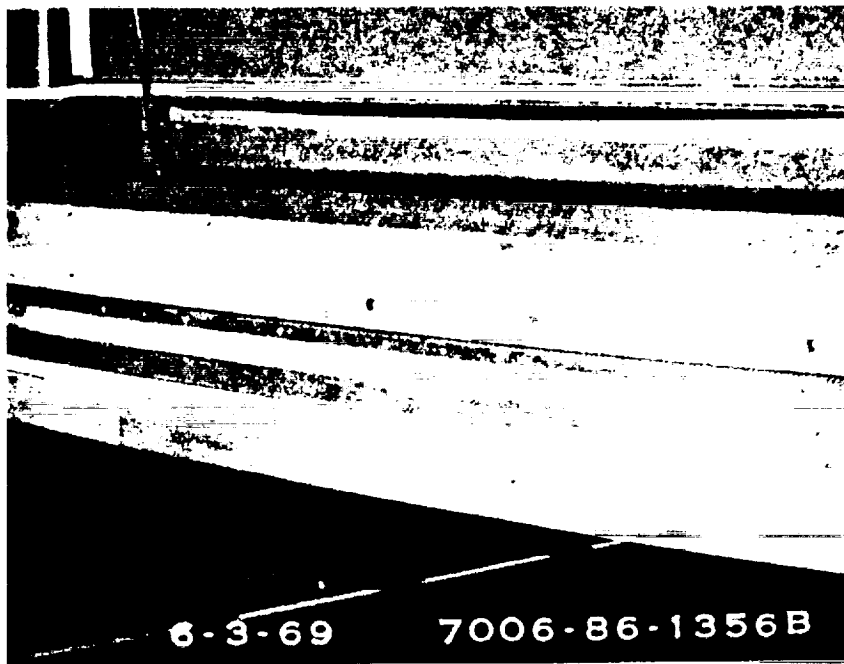


Figure 7-6. Set Screw Installation



Figure 7-7. Vacuum Line Connection

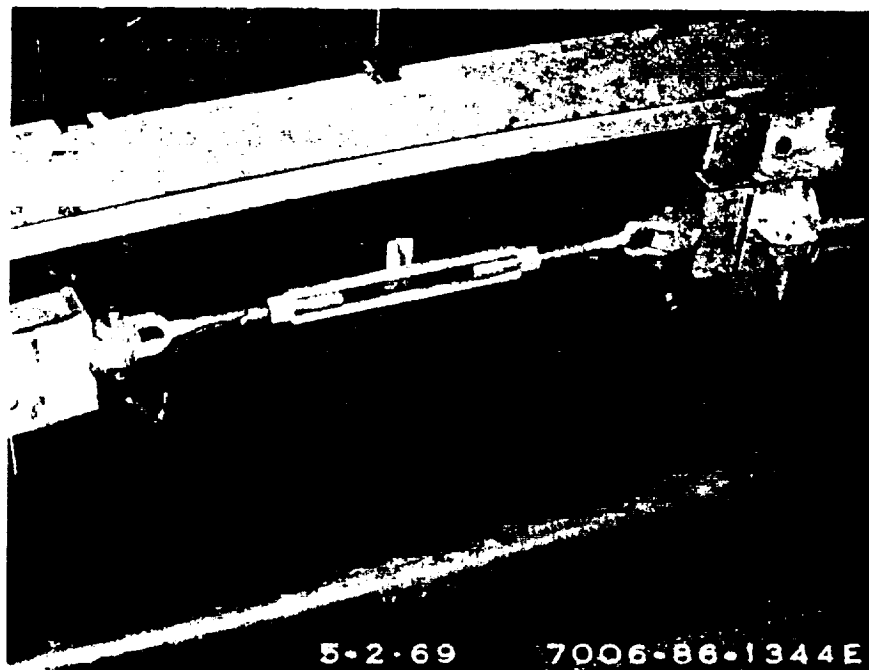


Figure 7-8. Chip Catcher Installation



CAUTION

Use only tape approved for use on the S-II stage.

7.3.8 The dust is wiped from the lower vacuum chucks of the circumferential sizing tool, using acetone-dampened cheesecloth to wipe the surfaces.

CAUTION

Acetone is flammable. Use only approved plastic bottle containers. Do not use acetone in open pans.

7.3.9 One set of lower vacuum chucks is located to the inboard wall of Cylinder 5. The top edge of the vacuum chucks must be kept level to the bottom edges of the Mylar tape markers placed 8 inches below the butt edge of the cylinder. The first chucks on the ends of the tool must be centered between the first and second vertical grids from the vertical welds on the cylinder. Three men are required to position the chucks (Figure 7 - 9). As the chucks are aligned to the cylinder, the vacuum line from the chucks is hooked to the vacuum manifold, thus opening the line to vacuum to secure the chucks. The chucks are tapped lightly to help seat them and prevent vacuum leaks (Figure 7 - 3).

7.3.10 The 8 chucks around the cylinder are aligned and the system is checked for vacuum leaks. Spreader links are installed between the ends of the 8 vacuum chucks. The ends of the spreaders are tied to the chuck frame by means of a ball lock pin in each end (Figure 7-10). The 8 spreader links are expanded by hand. This forms a full circle of the vacuum chucks and helps to support the chucks in case the vacuum supply fails (Figure 7 - 11).

7.3.11 Two vacuum cleaners are moved inside the cylinder and the intercom phone systems are hooked up inboard and outboard.

7.3.12 Numbered tape strip is applied below the weld land area of Cylinder 5 on the outboard side. The tape strip is numbered every 3 inches starting at zero. When applying the strip, the zero mark is located at Position I on Cylinder 5. Approved tape is used to hold the numbered tape strip to the cylinder (Figure 7 - 5).

7.3.13 Inspection checks the thickness on the Cylinder 5 weld land at each 3-inch increment. Measurements are taken with a micrometer and logged on an ITI-SB121 form (Figure 7-12). Any out-of-tolerance areas which are undersize are submitted to Material Review for disposition. Areas which are oversize will be draw-filed to tolerance. The ITI-SB121 form is logged in the FAIR book.



Figure 7-9. Positioning Lower Vacuum Chucks



Figure 7-10. Ball Lock Pin Installation

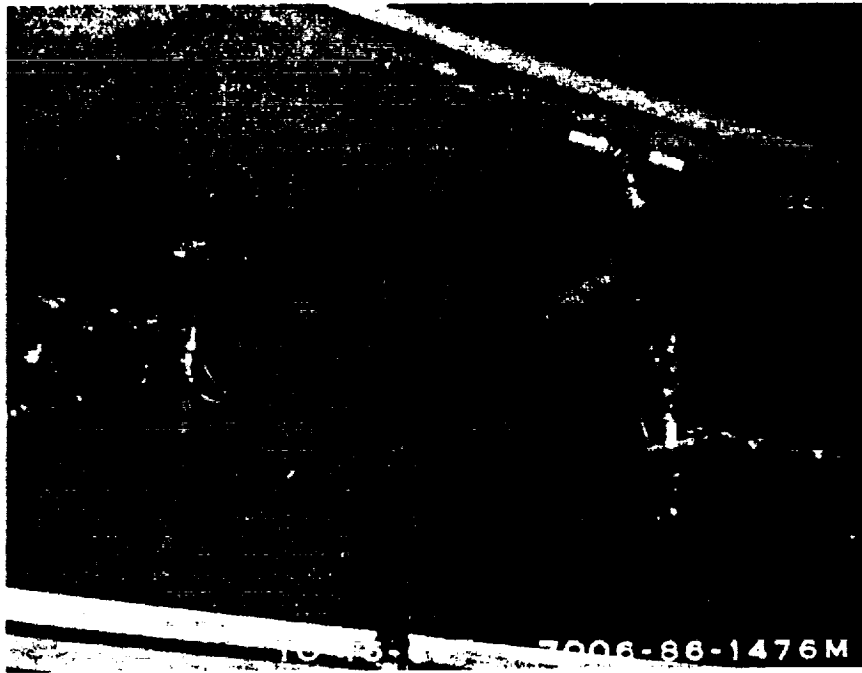


Figure 7-11. Spreader Link Installation



Figure 7-12. Weld Land Thickness Verification

7.3.14 The Cylinder 6-forward bulkhead assembly is moved into the building on the transfer table. The assembly is raised and moved into the station above the lower cylinders. The detailed move procedures are covered in MHP-A-08-S-II.

CAUTION

This is a safety-critical item. The move operations are performed by the riggers and a move conductor with Manufacturing supervision in attendance to assure adherence to safety practices. The move conductor must be in attendance throughout all phases of the move. Inspection documents the move sequence.

7.3.15 The Cylinder 6 assembly is lowered so that its lower edge is about 12 inches above Cylinder 5. Cylinder 6 is rotated to align the Position I marks on both cylinders. Four spacer blocks are installed to stabilize the cylinder, securing the spacer blocks with pastic-coated C clamps (Figure 7-13).

7.3.16 Using a 12-inch combination square, the 3-inch increment marks are transferred from the numbered tape strip on the outboard side of Cylinder 5 to the inboard side of Cylinder 6. The head of the square is placed on the butt edge of Cylinder 5 with the scale projecting 5 inches below the butt edge to the tape on the outboard side of Cylinder 5. The upper end of the scale is on the inboard side of Cylinder 6 (Figure 7-18). One edge of the scale is aligned on an increment line on the Cylinder 5 tape, and the tape on the inboard side of Cylinder 6 is marked with a marking pen. The increment marks are numbered to correspond to the Cylinder 5 tape.

7.3.17 Inspection checks the thickness of Cylinder 6 as previously defined for Cylinder 5. Inspection logs the pi-tape readings of the Cylinders 5 and 6 circumferential weld lands in the FAIR book. These readings were taken previously during cylinder buildup and after the cylinders were trimmed. Any dimensions out of tolerance will be submitted to MR for disposition.

7.3.18 The support saddles (T-7204189) are positioned at 24 equally-spaced points on the top edge of Cylinder 5. The saddles are checked for clearance before installation to be sure they do not scratch or mar the cylinder (Figure 7-14).

7.3.19 The four cylinder-stabilizing spacer blocks installed during Cylinder 6 loading operations are removed. Cylinder 6 is lowered into the saddles on Cylinder 5. Manufacturing personnel are positioned at six equally-spaced points to guide the bottom edge of Cylinder 6 into the saddles. Both the cylinder and handling fixture must be balanced to maintain a level plane within 1 inch during lowering operations (Figure 7-15).



Figure 7-13. Spacer Block Installation



Figure 7-14. Cylinder on Support Saddles



CAUTION

Do not allow the edge of the cylinder to bump saddles or any equipment.

7.3.20 As the cylinder is being lowered, the two cylinder Position I marks or the systems tunnel attach holes are aligned. Rotation need only be held within $\pm 1/2$ inch at this time. The systems tunnel is approximately 6 feet counterclockwise from Position I.

7.3.21 The crane is removed from the assembly and the outer sections of the fourth floor are lowered. The curtain on the third floor is closed. Tooling is loaded on the internal platform after installation of Cylinder 6 via the hoist on the internal platform (Figure 7-16).

7.3.22 One-inch Mylar tape is applied to the inside of Cylinder 6, 2 inches above the lower horizontal rib. The tape is applied between the vertical ribs around the entire circumference (Figure 7-17). Masking tape is applied over the Mylar tape.

CAUTION

Masking tape must not be applied to the cylinder wall.
Apply only over the Mylar tape.

7.3.23 Stringer-end protectors are installed on the stringer ends of Cylinders 5 and 6 to protect the stringer ends during installation of circumferential sizing tools and during cleaning of the weld joint (Figure 7-19).

7.3.24 A sheet vinyl or kraft paper seal is installed from the fourth floor to the cylinder wall. Sufficient material must be allowed so that the cylinder can be raised and lowered during preweld operations (Figure 7-20).

7.3.25 The third floor is wet-mopped, and all bench tops, bin tops, and exposed beams in the station are dusted. Operation of the shoe brush in the airlock entrance to the station is checked. Temperature in the weld station should be 76 F minimum. The humidigraph on the third floor is checked; humidity reading in the weld station should not exceed 50 percent. If temperature or humidity exceed allowable tolerances Maintenance is called

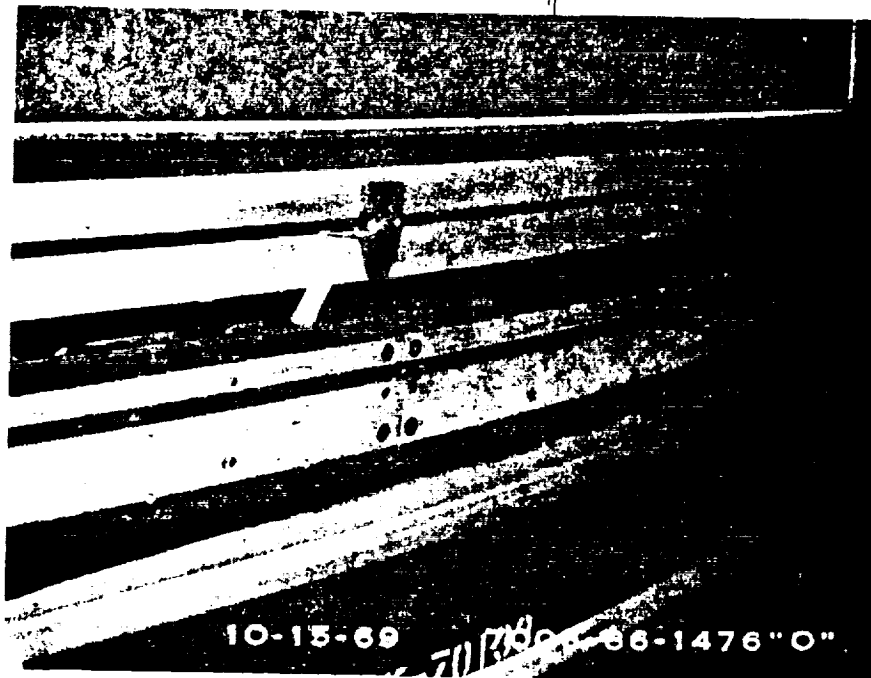


Figure 7-15. Cylinder Positioned in Saddles

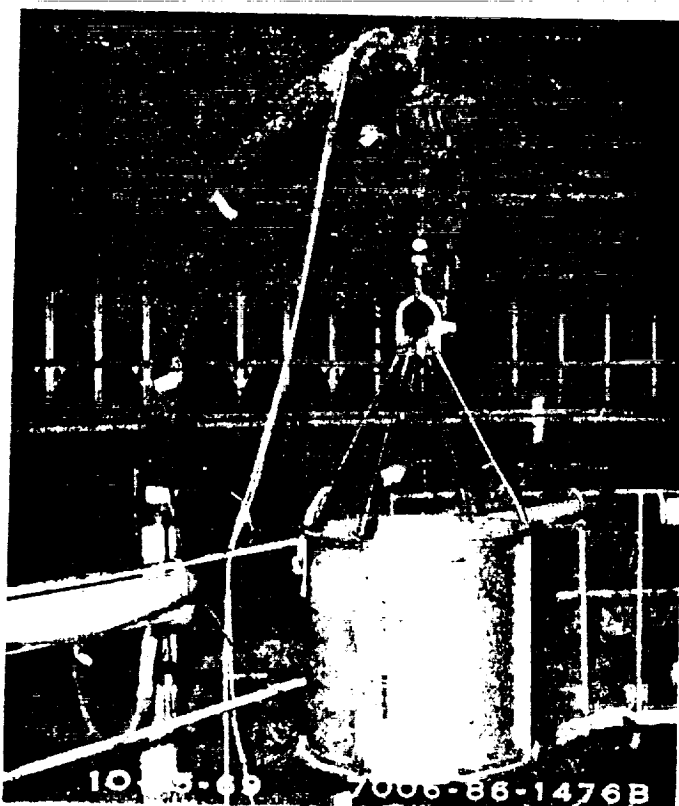


Figure 7-16. Inboard Hoist

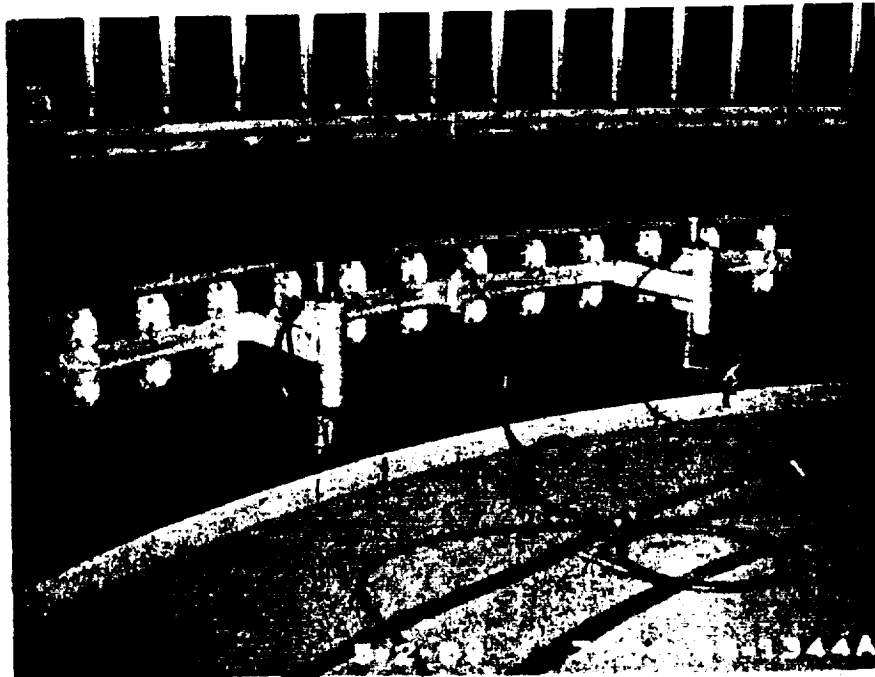


Figure 7-17. Application of Tape Inboard

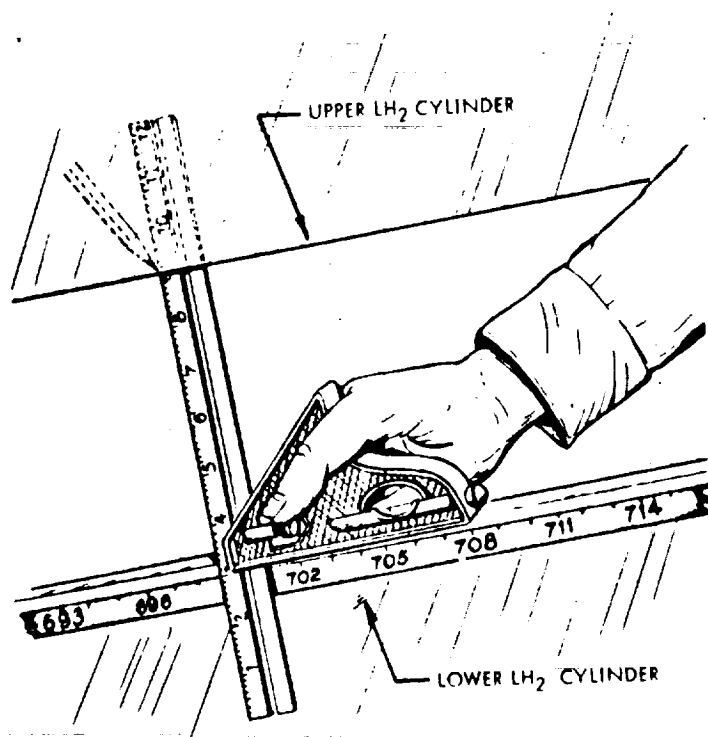


Figure 7-18. Transfer of 3-Inch Increment Marks

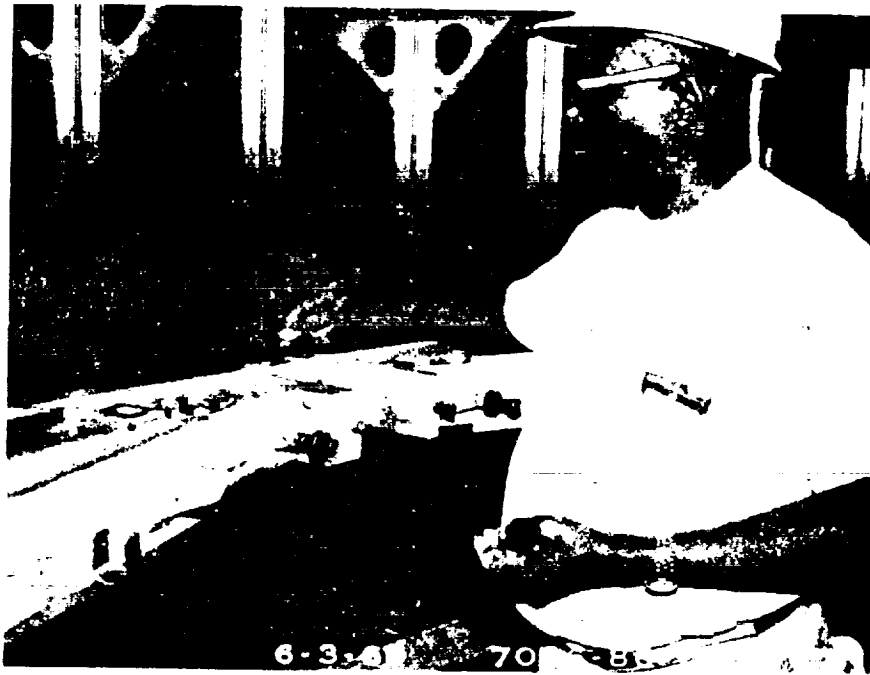


Figure 7-19. Installation of Stringer End Protectors



Figure 7-20. Fourth Floor-Cylinder Seal



to correct the condition. These operations should be performed and completed on the shift prior to starting the weld operation.

7.3.26 At the beginning of the shift on which the weld operation starts, the crane and the spreader bar are attached to the overhead handling fixture. Eight holes are cut through the seal installed in Step 7.3.24 for attachment of hoist pigtails to the fittings bolted to the Cylinder 6 bolt ring.

7.3.27 The Cylinder 6 assembly is raised with the overhead crane. The four spacer blocks are reinstalled at the vertical welds to keep the cylinder from rotating and swaying. The crane remains attached, supporting the cylinder during the weld operations.

CAUTION

Cover the clean spacer blocks with aluminum foil.

7.4 VERIFICATION PANELS

7.4.1 These panels are run prior to preweld cleaning as described in Section 1.14.

7.5 PREWELD CLEANING

7.5.1 Preweld preparation and cleaning procedures are conducted as described in Section 1.12. After completing the draw-filing operation, all chips are vacuum-cleaned from weld land areas. One safety spacer block is removed at a time and the areas covered by the four spacer blocks are draw-filed. The spacer blocks are reinstalled after filing and vacuuming the areas. The tooling and floor are vacuum-cleaned to remove chips. The cleaned edges of the cylinders must not be touched with the vacuum hose.

7.6 WELD TOOLING SETUP

7.6.1 During the precleaning operations, the 8 circumferential sizing tools are washed with acetone using clean cheesecloth. Circumferential sizing tools are checked for nicks and burrs on the fingers which come in contact with the weld lands. The defects are filed with a mill file and washed with acetone using clean cheesecloth. The circumferential sizing tools are wrapped with kraft paper and stored on the third floor outside of the cylinder.

7.6.2 The 16 supports (K) are installed in the lower supports (B) as shown in Figure 7-21. The height is adjusted using the wing nut (L). The top of the crossbar should be set 2 inches below the top edge of Cylinder 5.

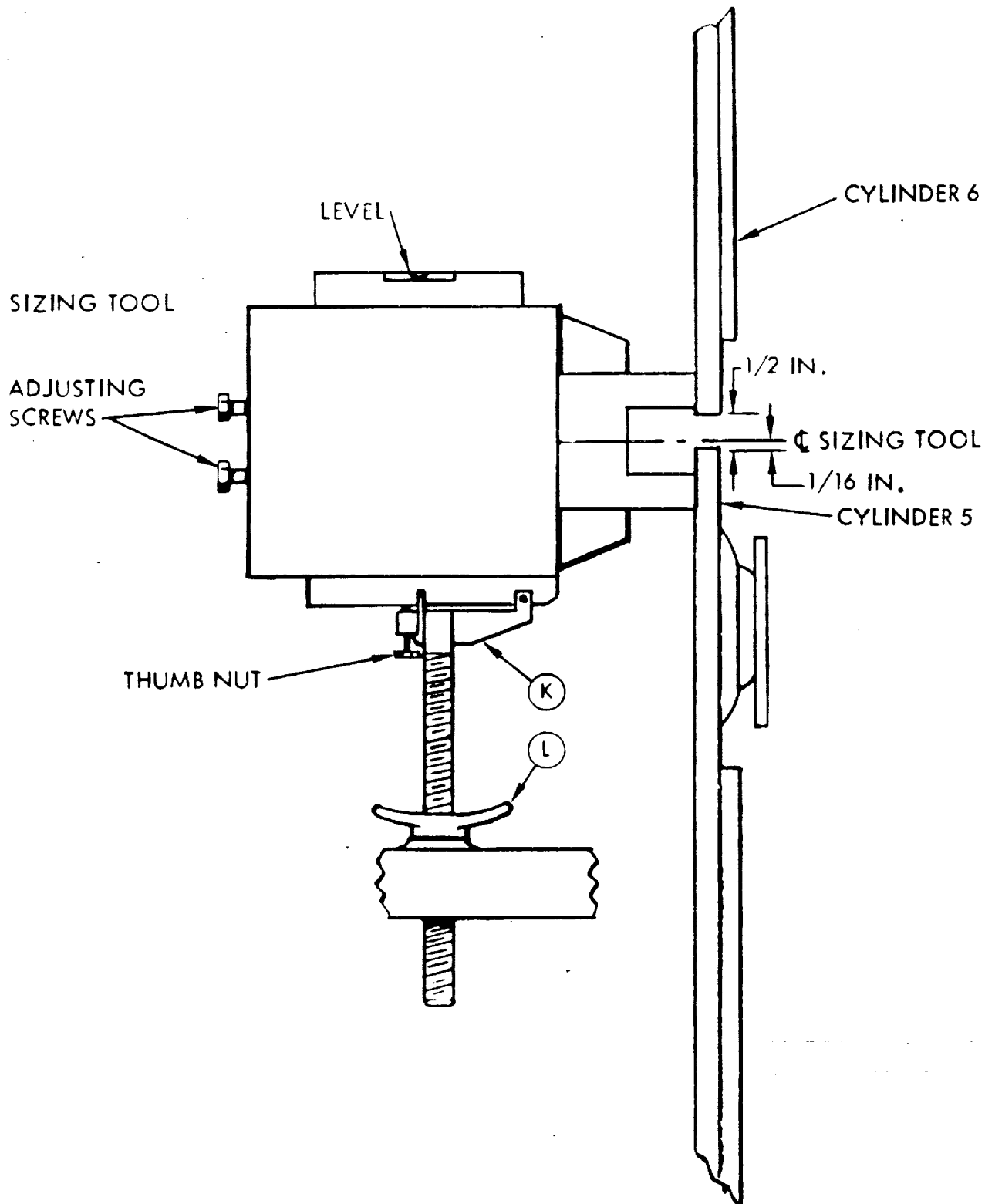


Figure 7-21. Height Adjustment



7.6.3 The center T-supports are installed on the channel by hooking supports over the top flange of the channel. The set screw is then adjusted to level the top of the supports. The height is adjusted using the wing nut. The top of the crossbar should be set 2 inches below the top edge of Cylinder 5. One of these supports is installed in the center of each of the bottom vacuum chuck assemblies (Figure 7-22).

7.6.4 After precleaning of the cylinders is completed, the area is vacuum-cleaned.

7.6.5 When precleaning of the weld joint is complete and verified by blacklight inspection, the circumferential sizing tools (T-7204464) are installed. With the lights turned off, blacklight inspection is made of the cleanliness of the circumferential sizing tools and they are recleaned if necessary. The tools are heavy, requiring five personnel outboard and five inboard to handle them. The five personnel outboard lift the first tool and pass it through the open weld joint to the inboard crew. This operation is repeated for the other 7 circumferential sizing tools. The tools are coded on each end designating their position.

CAUTION

Circumferential sizing tools must not be allowed to touch the clean weld joint.

7.6.6 The spreader jacks (T-7204464) are wrapped in vinyl bags to provide protection if the hydraulic system develops a leak. The jacks are stored on the floor on the inboard side of the cylinder.

7.6.7 The four spacer blocks are removed. The cylinder is balanced on the crane by adding sand-filled bags on the inboard frame. The crane is used to lower the Cylinder 6 assembly to leave a 1/2-inch gap between Cylinder 5 and Cylinder 6. The last few inches of lowering is accomplished using the hydroset per MHP-A-08-S-II to give more precise control over the movement of the cylinder.

7.6.8 The spreader jacks are installed between the circumferential sizing tools at 8 locations. The spreader jacks are attached by means of 1/2-inch-diameter ball lock pins through the slotted holes. It may be necessary to pry the last two tools apart to install the last spreader jack. A turnbuckle placed between the ends of the circumferential sizing tools and then expanded will force the tools apart far enough to install the spreader jack (Figure 7-23).

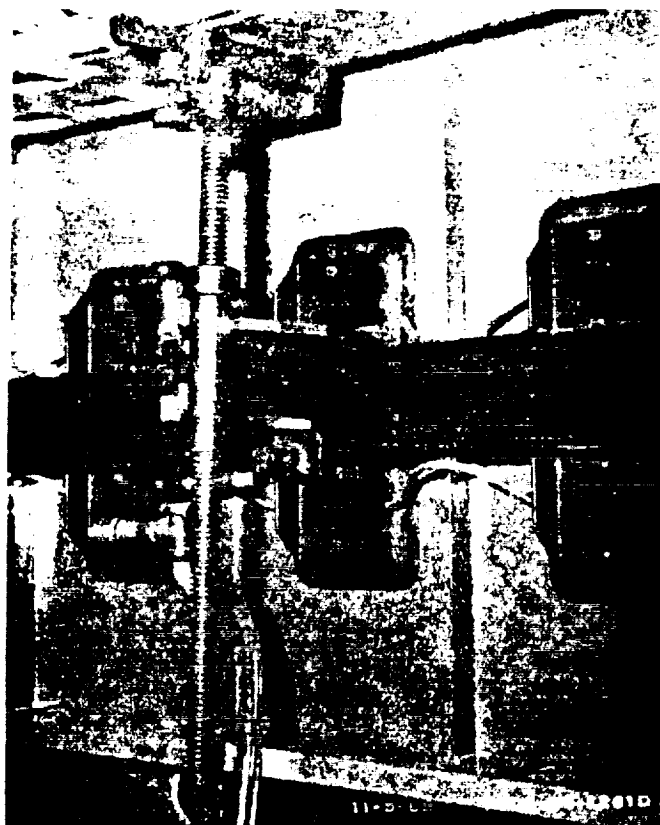


Figure 7-22. Center Sizing Tool Support

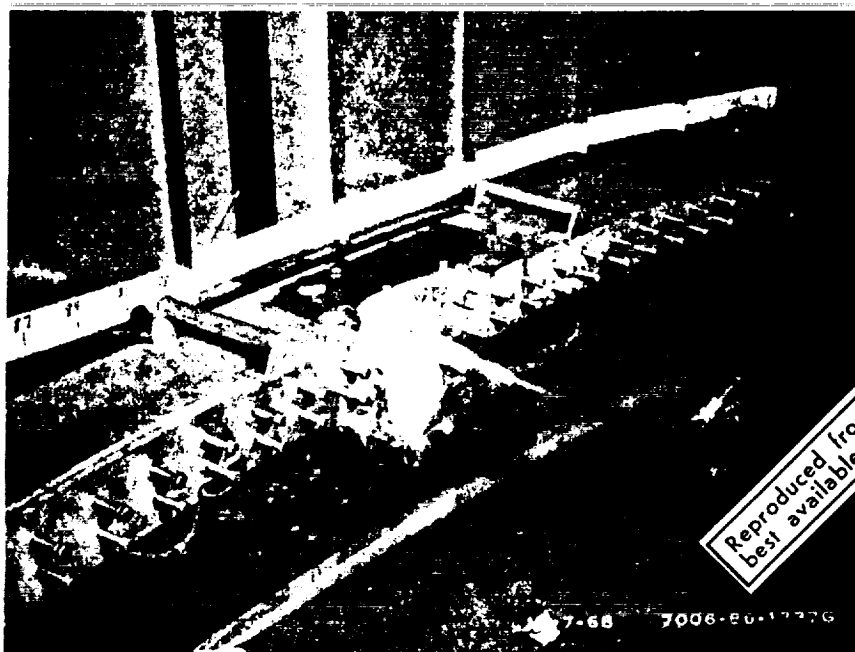


Figure 7-23. Offset Adjusting Screws



CAUTION

Do not allow tools to contact cleaned weld edges of the cylinders within 1/2 inch of the butt faces.

7.6.9 The dust caps are removed from the ends of the hydraulic lines attached to the spreader jacks, and the lines are connected to the hydraulic manifold. The valves are opened after hooking the hydraulic line into the system. The jacks must be covered with the vinyl bags.

7.6.10 The height of the circumferential sizing tools is checked. The top edge of Cylinder 5 must be 1/16 inch or less below the centerline of the circumferential sizing tool (Figure 7-21). The height of the circumferential sizing tool is adjusted by means of the adjusting wing nut (L). A bubble level is laid on top of the sizing tools and the tools leveled by means of the thumb nut on the support (K) (Figure 7-21).

CAUTION

Do not contact the cleaned surfaces of the cylinders while leveling the circumferential sizing tools.

7.6.11 A pressure of 3000 psig is applied to the hydraulic system to pressurize the circumferential sizing tools. Follow the instructions displayed on the hydraulic console. This operation should occur near a shift change.

7.6.12 The joint is covered with aluminum foil inboard and outboard using only approved tape to secure in place. The joint area must not be contaminated.

7.7 FINAL CLEANING OPERATIONS

CAUTION

All personnel must wear clean white smocks, caps, and nylon gloves while performing the following operations.

7.7.1 The aluminum foil is removed from the weld joint and the joint is prepared as described in Section 1.

7.7.2 Using clean vixen files, final cleaning operations are made on the outboard faces and butt faces and the edges of the cylinders are leveled.



Cylinder 6 is cleaned first, then the chips are vacuumed, and the procedure is repeated for Cylinder 5. Only qualified personnel may be used for this procedure.

7.8 FINAL WELDING PREPARATION

7.8.1 After completion of the blacklight inspection, the rotational alignment tool (T-7203718) is installed. The alignment tool attaches to two of the tunnel left-hand attachment holes in Cylinder 5 and two of the left-hand holes in Cylinder 6. The tool is provided with bushings of 1/4-inch inside dimension and 3/4-inch outside dimension (Figure 7-24). Special screws, 1/4-28, are provided with the tool. These screws are installed through the bushings, which are slipped into the holes of the alignment tool. One of these holes in each half of the tool is slotted to allow for vertical tolerance between the tunnel attach holes (Figure 7-25).

7.8.2 The circumferential sizing tool pressure is lowered to 500 psig. Precleaned 0.040-inch stainless steel shims are installed at 12 equally spaced points around the circumference of Cylinder 5. The spacers are taped to Cylinder 5 below the cleaned area with Mylar tape. One leg of the shim, approximately 1/2- to 3/4-inch long, must rest on the Cylinder 5 butt edge as shown in Figure 7-26. These shims are used to prevent Cylinder 6 from bearing on Cylinder 5 during the lowering and rotational alignment operations.

CAUTION

The shims are cleaned with acetone prior to installation. Do not contaminate the shims during installation. Only approved tape may be used on the cylinder surface.

7.8.3 Cylinder 6 is lowered using the crane and hydroset. Up-and-down pressure is applied manually to maintain a near-constant gap. The lowering operation is monitored from the outboard side of the cylinders and the rotational alignment checked as the cylinder is lowered.

7.8.4 The Cylinder 6 assembly is lowered to leave an approximate 1/8-inch gap between the cylinders around the circumference. Rotational alignment is checked by aligning the pointer on the upper alignment tool with the scale on the lower tool. Tolerance must be kept within 0.030 inch. The pressure can be lowered below 500 psi, but care must be taken that the upper cylinder does not shift, causing the butts of the joints to bump.

7.8.5 If the pressure has been lowered for rotation, circumferential sizing tools are pressurized to 500 psi. Cylinder 6 is lowered at Position I

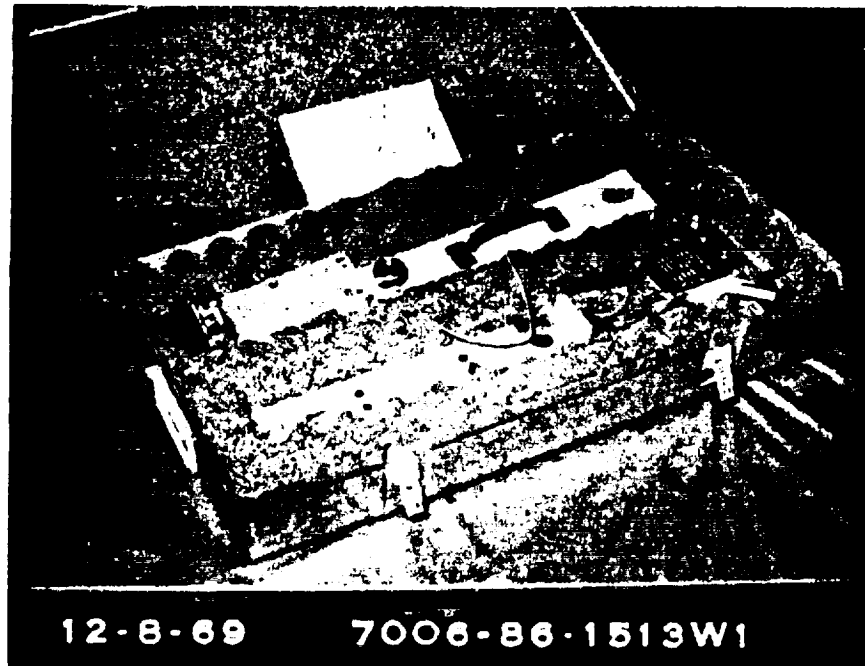


Figure 7-24. Alignment Tool



Figure 7-25. Alignment Tool Installed

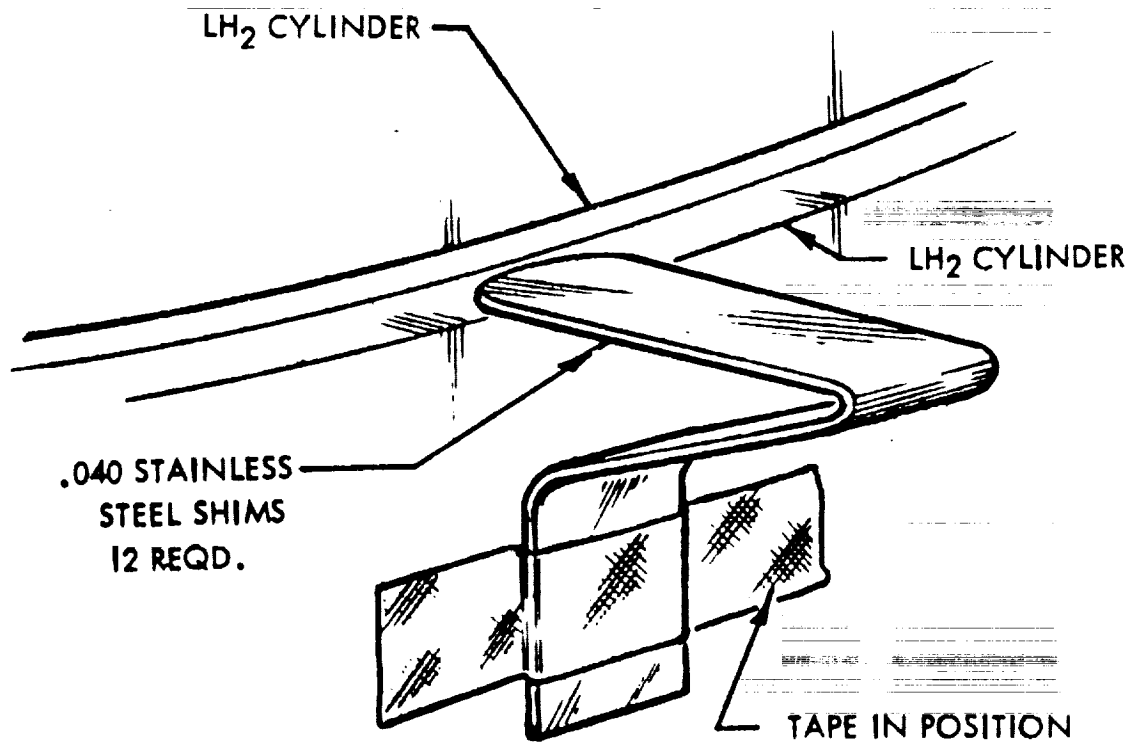


Figure 7-26. Stainless Steel Shims Installed



to leave a gap of approximately 0.040-inch and the rotational alignment is checked again. The circumferential sizing tools are pressurized to 6000 psig.

CAUTION

Only qualified personnel operate the hydraulic pump.
Inspection verifies rotational alignment and clears
the item in the FAIR book.

7.8.6 The stringer end protectors are removed from the stringer ends of Cylinders 5 and 6. Verification of approval to weld is made in the FAIR book. Inspection approval is required before proceeding with tack welding.

7.8.7 During the final cleaning operation, the welders and the weld engineers verify the equipment. The gas is checked for moisture content, the wire is checked, and the heat treat number, size, etc., are logged in the FAIR book. A bead-on verification plate is run as described in Section 1.14 and checked by Quality Control, which also checks the machine settings. The weld heads are then removed to the skate track at each weld position. The welder connects the sensing and ground leads to the assembly and these are checked by the weld engineer.

7.9 WELDING OPERATIONS

7.9.1 Two tack-weld teams are utilized for the circumferential welds. Each team consists of a welder, an offset manipulator, and a vacuum hose operator outside the cylinder, and an offset manipulator inside. The teams operate approximately 180 degrees apart. Two other men, one on the outboard side and one on the inboard side for each weld station, preset the offset ahead of the tacking crew.

7.9.2 Communication between the personnel outboard and inboard is by means of the intercom headsets (Figure 7-23). Using a 0.050-inch thick stainless steel gauge, the manipulator checks the offset and informs the team member on the inboard side which cylinder must be moved to arrive at the target of 0.010-inch offset. The inside team member adjusts the offset by means of the bolts on the inboard side of the circumferential sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers.

7.9.3 The first tack is located at approximately Position I where a 0.040-inch gap exists. The offset is set by the manipulating team. The joint area is vacuumed to remove any foreign material from the faces of the



cylinders, using care not to touch the surfaces. The weld head is then moved into position for the first tack, and locked to the gear rack on the track. The weld machine is programmed per the 971-D-00265 Weld Schedule for the intermittent tack pass, the torch is positioned for the tack, the circumferential sizing tool pressure of 6000 psi is verified, and the first tack is made. A 3-inch long tack is run and the machine tapered out. A space of 6 inches is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for 4 to 5 tacks. The rotational alignment tools and the 0.040-inch stainless steel shims then are removed.

7.9.4 The gap around the cylinders is checked. If the gap 180 degrees from the first tacks exceeds 0.040 inch, an area near that with less than a 0.040-inch gap is used to start the tack pass operations of the second tack weld team. The same offset alignment procedure is used.

7.9.5 The two weld teams work progressively, tack-welding the cylinders with 3-inch long tacks at 9-inch centers. Each team welds approximately one-half of the circumference. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.0-15 inch offset after welding is checked by supervision and reworked if required.

7.9.6 After tacking operations are complete, the circumferential sizing tool centering is checked. The sizing tool pressure is dropped and the tool recentered on the weld joint if required. The tool is then repressurized to 6000 psig. All adjusting screws are backed off and readjusted finger-tight to assure contact of the sizing tools with the cylinders.

CAUTION

Do not over-tighten screws.

7.9.7 The weld machine parameters are checked and the weld machine programmed per the 971-D-00265 Weld Schedule for the continuous tack pass. The two weld machines are moved so they are 180 degrees apart and in position so that the cables will reach around the 180 degrees to be welded by each machine. An air motor with a 1/4-inch ball rotary file is set up at each area. This is used to grind out the minute crater cracks left when the weld machine sequences out after running the continuous tack pass.

7.9.8 The continuous tack pass is run with each machine overlapping the start of the other machine for a minimum distance of 6 inches or until a good tie-in is made. As each machine sequences out for any reason, the tailout crater is ground out as soon as the welding arc is terminated so that any small cracks will not propagate.



7.9.9 As the continuous tack pass cools, the circumferential sizing tools are again checked for centering and adjusted. If recentering is required, the pressure is reduced, and the tools recentered. The tools are repressurized to 6000 psi.

7.9.10 Using a clean, fine, stainless steel rotary brush in an air motor, the entire continuous tack pass is brushed. The brush is moved in long strokes in one direction only. Dust and soot are vacuumed from the area. Do not touch the surface of the weld land with any material except the wire brush.

7.9.11 The two weld machines are moved back into start position defined for the continuous tack pass. The machines are reset to the penetration parameters per the 971-D-00265 Weld Schedule, and inspection verification is obtained. The current override control is moved to the inside of the cylinder, and the control switch on the weld pack is turned on.

7.9.12 The following preparations for the penetration pass are checked and verified:

- a. Intercom system between inboard and outboard at each weld station.
- b. Circumferential sizing tool pressure and centering.
- c. Position of operators on the inboard side and intercom contact with the welders on the outboard side.
- d. Presence of air motor with 1/4-inch ball rotary file at each weld area.

7.9.13 The operator on the inboard side controls the amount of drop-through on the penetration pass and also is responsible for tracking the seam. The drop-through is watched by means of sight holes in the backup bars.

7.9.14 The penetration pass is run, with each machine overlapping the penetration weld of the other machine a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground out to a depth of approximately 0.060 inch, using the 1/4-inch ball rotary file. All tailout craters are checked to assure removal of defects.

7.9.15 The drop-through side of the weld is checked for incomplete penetration. If any defective areas exist, the weld machine for that area is moved into position and the optional pickup pass is made per the weld schedule.



7.9.16 White garments are not required for the following operations. After the penetration pass or optional pickup pass operations are complete, the circumferential sizing tool pressure is released.

7.9.17 Stringer end protectors are reinstalled on the stringer ends of Cylinders 5 and 6 and the 8 spreader jacks and circumferential sizing tools removed. Tooling is stored neatly on the inboard side of the cylinder on the internal platform.

CAUTION

Do not remove the lower chucks.

7.9.18 The drop-through side of the weldment is inspected for undercut, incomplete penetration, folds, etc., per Specification MA0107-016. Inspection verifies the drop-through and prepares a squawk if required.

7.9.19 Using three or four weld shavers, the weld bead on the inboard side is milled to a height of 0.010 to 0.015 inch. Do not cut into parent metal with the shavers (Figure 7-27). A Bear-Tex wheel in an air motor, is used to abrade the inboard side of the weld. Long, even-pressured strokes are used in abrading without pausing in any one area, which causes high or low spots (Figure 7-28). Do not run Bear-Tex wheels crosswise or at angles to the weld.

7.9.20 A fine stainless steel rotary brush is used to remove the soot from the outside of the weld. The penetration pass (outboard) is checked for any folds, etc., which can be blended out prior to X ray. Blending is done with ball rotary files. Inboard and outboard welds are wiped using acetone-dampened clean cheesecloth.

7.9.21 The penetration weld pass is X-rayed and the report prepared. Defects identified are evaluated by the Manufacturing supervisor and weld engineer to determine which should be reworked prior to putting the cover passes on the weld. A Manufacturing Request for Rework (Form 021S) is filed requesting planning tickets for in-process rework. Defective areas are reworked per procedures outlined in Section 10.

7.9.22 Circumferential sizing tools are reinstalled following procedures previously described. The spreader jacks are pressurized to 6000 psig, and checked for hydraulic leaks.



Figure 7-27. Milling Weld Bead



Figure 7-28. Abrading Weld Bead With Bear-Tex Wheel



CAUTION

All personnel must wear white nylon gloves, coats, and hats during the following operations.

7.9.23 A clean fine stainless steel rotary brush in an air motor is used to brush the outboard side of the weld. Long strokes in one direction only are used.

7.9.24 Weld machines are reset for the cover pass weld per Weld Schedule 971-D-00265; override control remains off. Bead-on plate panels are run to verify equipment function.

7.9.25 The stringer end protectors are removed from the stringer ends of Cylinders 5 and 6. Circumferential sizing tool pressure is rechecked and air motors with a 1/4-inch ball rotary file are positioned at each weld machine area. The two weld heads are moved back to the start position.

7.9.26 The first cover pass is run with the operator making sure that it covers the bottom edge of the penetration pass. The cover passes overlap at least 6 inches before sequencing out.

7.9.27 The tailout craters are ground out with a ball rotary file. The cover pass is wire brushed and the entire cylinder circumference is inspected for lack-of-fill areas. If they exist, the decision is made whether to run a complete second cover pass or intermittent pickups.

7.9.28 A second cover pass, if required, is run as defined for the first cover pass. If intermittent pickups are required, the weld machine is moved to each area and the operation performed. After the second cover pass or intermittent pickup passes, the weld is inspected for defects.

7.9.29 Spreader jacks and circumferential sizing tools are removed and stored neatly on the inboard side of the cylinders on the internal platform.

7.9.30 Using three or four weld shavers, the cover passes are milled from 0.010- to 0.015-inch height. Do not touch parent material. The milled weld bead is abraded with a Bear-Tex wheel in long strokes. Do not abrade across the bead.

7.10 POST-WELD OPERATIONS

7.10.1 The entire weld is X-rayed, the film read out, and triangulation shots made of any questionable areas. Any rework accomplished by the in-process method or by MR action will be performed as described in



Section 10. After X-ray is complete, the joint is inspected with fluorescent penetrant both inboard and outboard. Manufacturing personnel assist fluorescent inspection personnel by blending out defects if they do not lie below parent material thickness.

7.10.2 After the X-ray and fluorescent inspections are completed, company and NASA inspection verify the sequences in the FAIR book.

7.10.3 The inboard and outboard sides of the weld are then Chem-filmed using the following procedures:

- a. The weld land is wiped with acetone-dampened cheesecloth (rubber gloves must be worn).
- b. The weld is deoxidized by abrading with a Bear-Tex pad, rubbing lightly by hand.
- c. A dry clean cheesecloth pad is used to wipe clean.
- d. Chem-film solution is applied using a clean cheesecloth pad.
- e. After 3 to 5 minutes, excess solution is removed with a cheesecloth pad and deionized water.

7.10.4 After Chem-film has dried a minimum of 12 hours, black vinyl corrosion-preventive tape is applied.

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8.0 LO₂ GIRTH WELD

8.1 GENERAL DESCRIPTION

8.1.1 The techniques and procedures for the circumferential welding of the aft LO₂ bulkhead to the aft facing sheet of the common bulkhead assembly (LO₂ girth weld) are described in this section. The girth weld is performed in Station 3 of the vertical assembly building. The aft LO₂ bulkhead is welded to the aft facing sheet after the common bulkhead has been joined to the Cylinder 1-Cylinder 2 assembly and the bolting ring attached. The support tool (T-7200015) is used to support the assembly for the girth weld operation. The joint offset is controlled during welding by an internal circumferential sizing tool (T-7204464). Utilizing two welding machines, a direct-current gas tungsten arc (DC-GTA) weld is made using the square-butt joint configuration.

8.1.2 Reference documents applicable to this procedure are as follows:

V7-300011	Structure Assembly Complete
V7-333002	LO ₂ Tank Assembly
V7-333102	LO ₂ Tank - Common Bulkhead Assembly
V7-333202	LO ₂ Tank - Aft Bulkhead Assembly
MA0107-016	Machine Fusion Welding of Aluminum Alloys, S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, S-II
MA0610-002	Surface Preparation for Application of Chem-Film
971-D-00550	Weld Schedule
TOS-556-0016	Internal Work Platform - LO ₂ Tank
TOS-556-0017	Trim Skate - Circumferential Weld
TOS-556-0038	Support Fixture - LO ₂ Tank Subassembly
MHP-A-13-SII	Position LO ₂ Aft Bulkhead onto T-7200015 Tool in VAB
MHP-A-14-SII	Position Common Bulkhead Cylinders 1 and 2 in the LO ₂ Bulkhead, Tooling Fixture (T-7200015)
MHP-E-14-SII	Assem/Install T-7200011 Work Platform in LO ₂ Tank
MHP-A-17-SII	Lift Complete LO ₂ Tank onto Simulated Aft Skirt
PRO-565-011	Girth Weld Common Bulkhead to Aft LO ₂ Bulkhead



8.2 LOADING THE STATION

8.2.1 All the floors in Station 3 are raised, the support tool (T-7200015) is moved into the center of the station, and the second floor is lowered. The protective cover is removed from the skate track on the support tool.

8.2.2 The tool is leveled by adjusting the leveling jacks of the stage dolly, using an optical sight sighted against white-faced scales (Figure 8-1). The scales are held against the four reference pins of the tool.

8.2.3 The valves at the upper end of the 12 fire hoses in the contour boards of the support tool are verified to be off. The fire hose system is connected to a water line and the 12 fire hoses are pressurized to 5 ± 2 psig. There are two systems with six hoses alternating on each system. This assures adequate support to the bulkhead in case of system failures.

8.2.4 The aft LO₂ bulkhead is moved into Station 3 on the transfer table and loaded onto the support tool.

CAUTION

This is a safety-critical item. The operation is performed by the riggers and a move conductor. However, Manufacturing has the responsibility to assure adherence to safety practices. The move conductor must be in attendance during all phases of the move.

8.2.5 Material Handling personnel load the bulkhead on the tool with an overhead crane. The detailed procedures are covered in Specification MHP-A-13-SII. The lower contour of the bulkhead rests on the fire hoses. The bulkhead must be rotated so Position I is approximately 5 degrees counterclockwise from its normal position. This positions the studs on the lower side of the bulkhead clear of the fire hoses (Figure 8-2). Two or three men must be stationed on the stage dolly to verify the clearance of the studs. The reference scribe mark at the upper trim line should be held level at the 4 position marks within 1/2 inch. The overhead crane is not disconnected until the bulkhead is leveled within this tolerance.

8.2.6 The work platform (T-7200211) is assembled on a dolly and moved into the VAB on the transfer table. The work platform is loaded into the bulkhead. The protective pads are then installed inside the lower bulkhead (Figures 8-3 and 8-4). Procedures for loading the platform are covered in Specification MHP-E-14-SII.

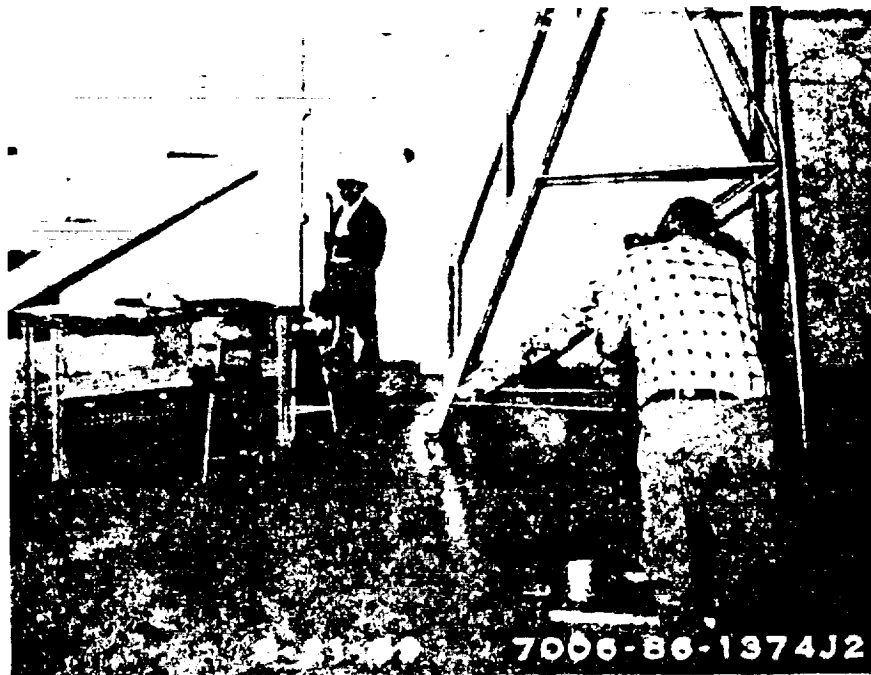


Figure 8-1. Leveling Tool

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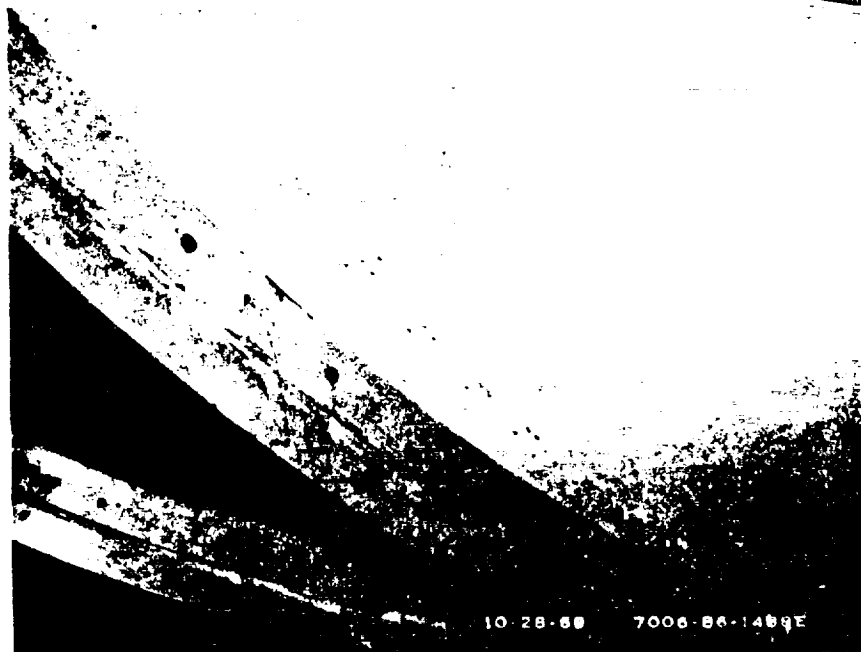


Figure 8-2. Stud Clearance

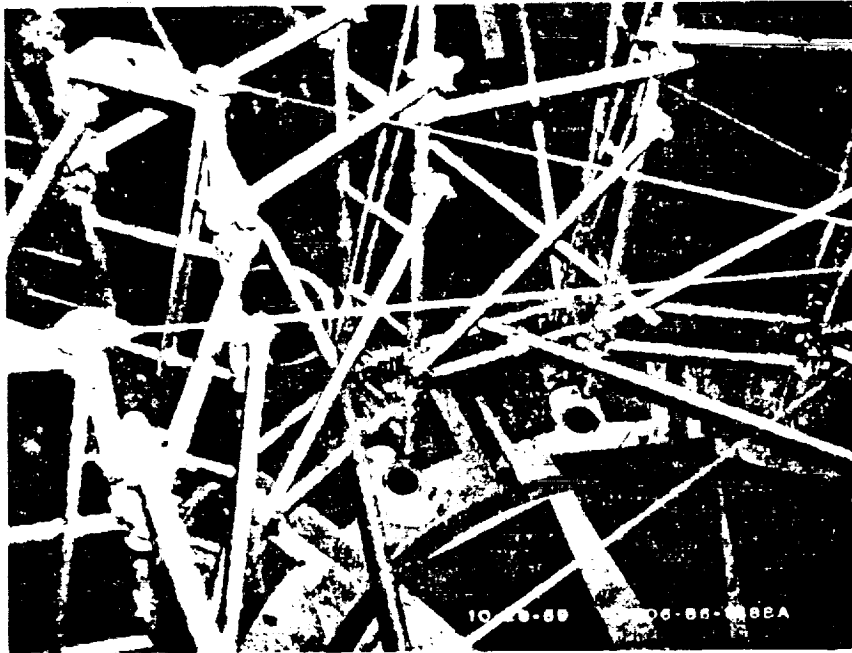


Figure 8-3. Bulkhead Protection

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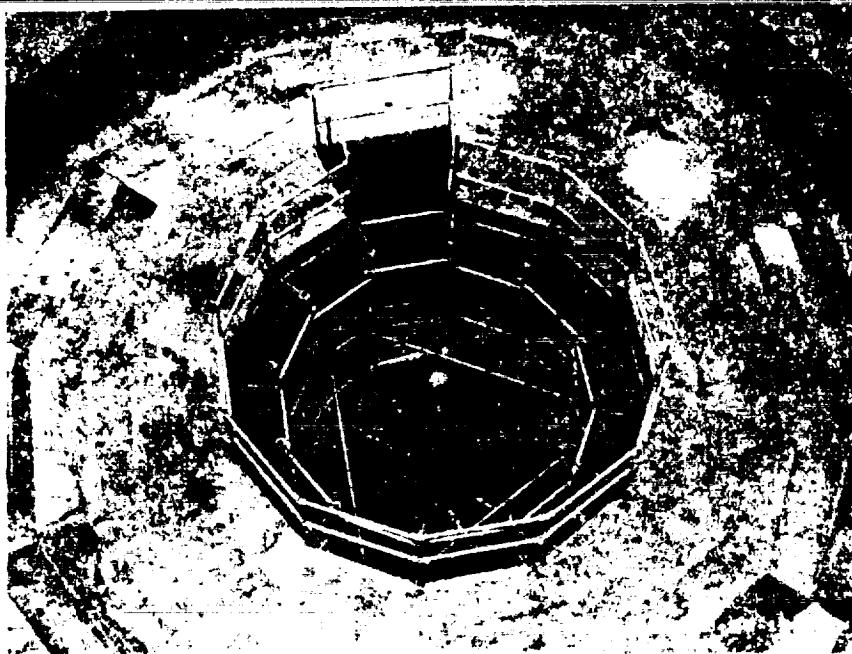


Figure 8-4. Work Platform Installed



8.2.7 A vinyl seal is installed from the work platform to the inboard surface of the bulkhead around the entire tank (Figure 8-5).

CAUTION

Use only approved tapes to seal the vinyl to the tank wall.

8.3 STATION PREPARATION AND TOOLING INSTALLATION

8.3.1 The inboard vacuum manifold is placed on the internal platform floor with the connecting line routed to the vacuum system on the first floor. The hydraulic manifold for the circumferential sizing tools is placed on the internal platform floor and connected to the hydraulic pump on the first floor (Figure 8-6). The system is tested by pressurizing it to 6000 psi and checking for leaks. The pressure is then reduced and the fluid level of the reservoir checked.

8.3.2 Electric power is connected to the power supply on the first floor. Ten encapsulated fluorescent lamps are installed.

CAUTION

Only approved electrical lines are used. Exposed metal plugs are not permitted.

8.3.3 The vacuum chucks of the circumferential sizing tool (T-7200016) supports are dusted. Acetone-dampened cheesecloth is used to wipe these surfaces.

CAUTION

Acetone is highly flammable. Only approved containers and plastic bottles are used. Do not use acetone in open containers.

8.3.4 The lower brackets of the circumferential sizing tool supports are clamped to the grid of the aft LO₂ bulkhead. A small slit is cut in the vinyl seal and the supports installed through the seal, supported by the lower bracket and the vacuum chucks. The vacuum lines are connected to the



Figure 8-5. Vinyl Seal Between Bulkhead and Platform

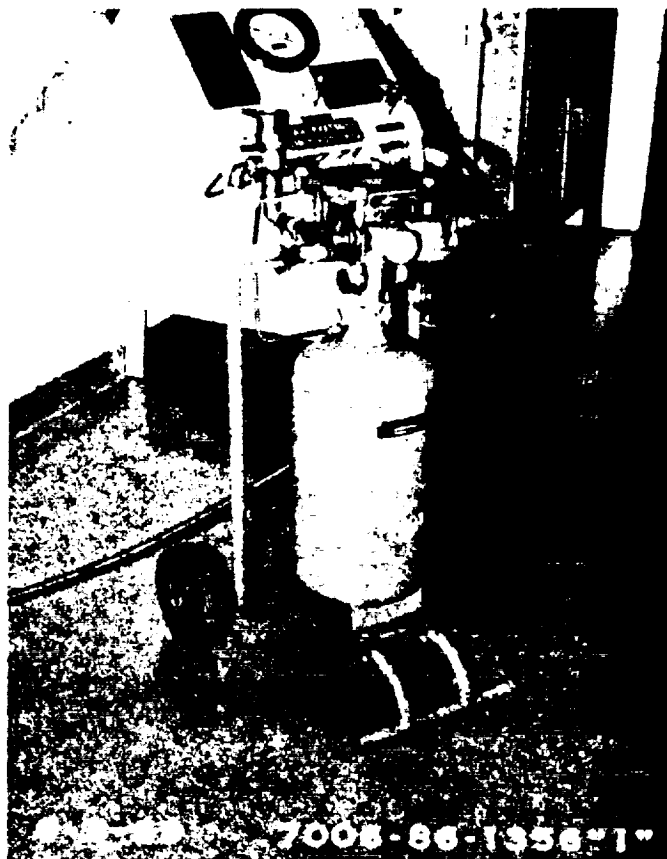


Figure 8-6. Hydraulic Pump



manifold and vacuum applied (Figure 8-7). The 16 supports are spaced so each will be 18 inches from the end of the circumferential sizing tool. The vacuum and hydraulic lines are attached to the supports.

8.3.5 The 8 circumferential sizing tool sections (T-7209016) are installed. The spreader jacks between the tools are pinned into position and connected to the hydraulic manifold. The circumferential sizing tool sections are used to size the bulkhead during the trimming operation only.

8.3.6 The supports are adjusted so that the centers of the circumferential sizing tool sections are the same height as the net trim line on the bulkhead.

8.3.7 The circumferential sizing tool sections are expanded with 3000 psi pressure. The purpose of the tool is to hold the bulkhead in a near round condition during trimming.

8.4 TRIMMING LOWER LO_2 BULKHEAD

8.4.1 The reference scribe mark on the bulkhead is 0.50 inch above the net trim line. This line is checked at the 4 position marks and the 4 fin lines for parallelism with the skate track. This check is made with a scribe on a skate (Figure 8-8). The position of the bulkhead is adjusted by jacking up the low areas and by adjusting the side vacuum pads in or out. Parallelism must be held within a range of ± 0.030 inch. The bulkhead is verified to be level and the FAIR book sequence is cleared by inspection.

8.4.2 Eight labels are applied at the four position marks and four fin marks approximately 1-1/2 inches below the scribe line.

8.4.3 A reference line is drawn with a pen 1-1/2 inches below the scribe line. This line is verified by the inspector and stamped. These lines are used to verify the final trim because the reference scribe line is removed during the trim operation.

8.4.4 The saw skate is run around the entire perimeter of the skate track to assure that there are no obstructions. The saw is inspected for wear. The saw is set up and adjusted so the cut will be approximately 1 inch above the reference scribe line (Figure 8-9).

8.4.5 The vacuum hose and air is connected to the saw and the rough trim is made around the bulkhead. During the sawing operation wedges are installed in the cut behind the saw to minimize binding of the saw blade. The area is vacuumed during this operation (Figure 8-10).

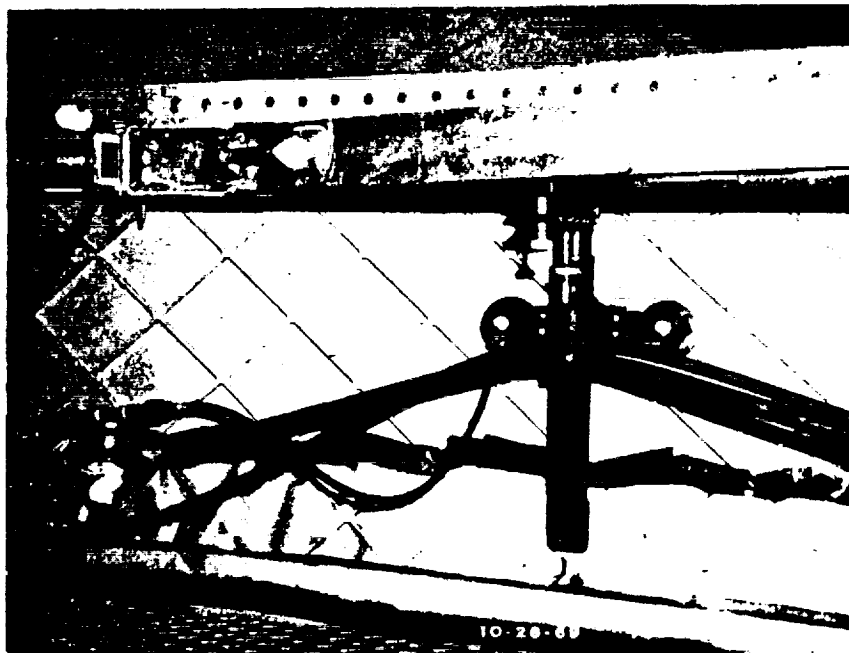


Figure 8-7. Installation of Lower Vacuum Sizing Tool Supports

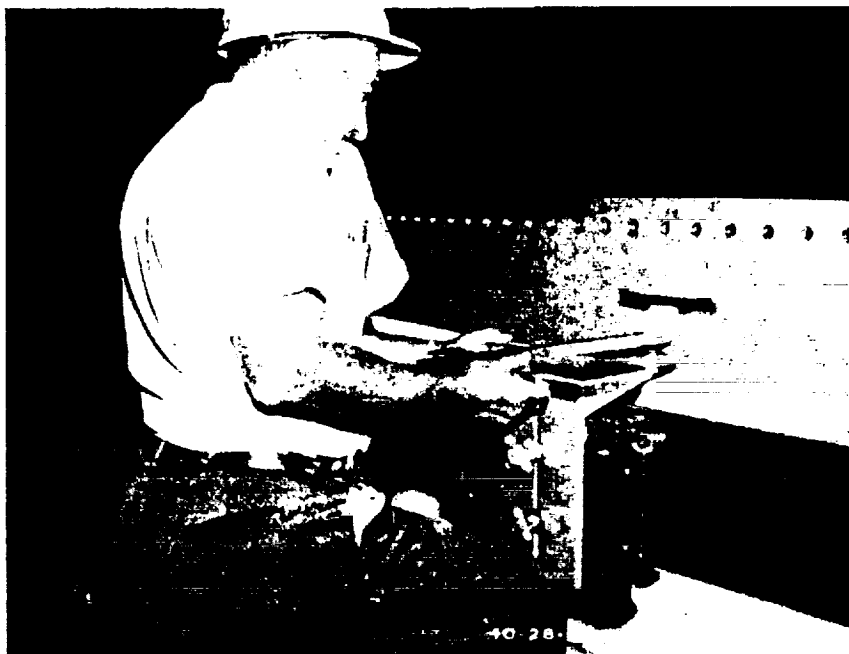


Figure 8-8. Checking Scribe Line

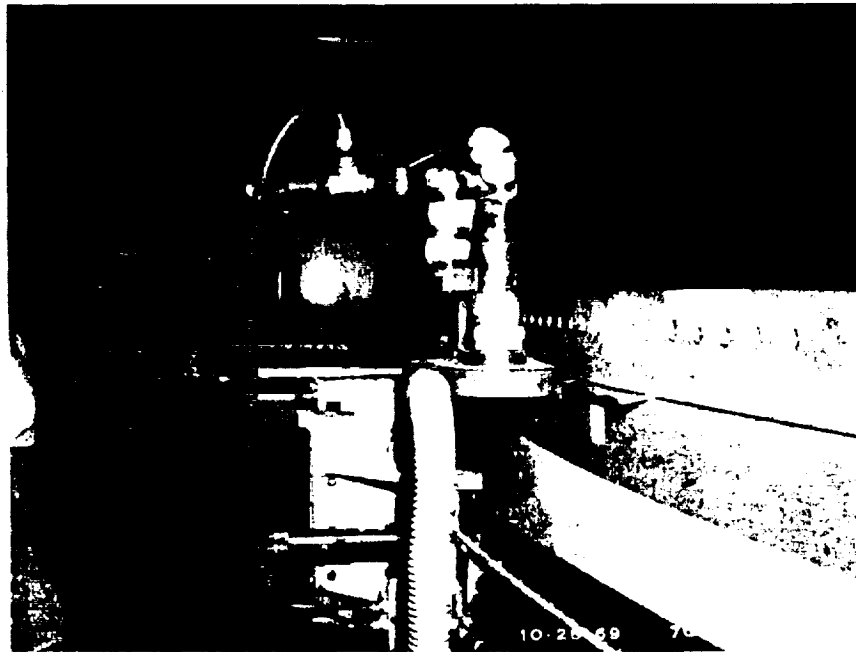


Figure 8-9. Saw Setup



Figure 8-10. Vacuuming During Sawing Operation



8.4.6 The trim material is cut in 4-foot sections and stored for weighing.

8.4.7 The scribe marks on the bulkhead are again checked for parallelism to the skate track prior to making the final trim. The bulkhead is re-leveled if required.

8.4.8 The final trim line is made 0.060 inch above the net trim line. The excess is to compensate for weld shrinkage. The height of the saw is set so its lower edge is 0.44 inch below the reference scribe line at the 4 position and fin locations.

CAUTION

The saw must cut above the trim line.

8.4.9 The saw blade is checked for damage and replaced if required.

8.4.10 The saw is connected to the vacuum hose and air supply and the final trim cut is made. This cut should be made in one continuous run with no stops. This operation will take approximately five hours.

CAUTION

Do not stop the saw as a step in the cut may result.

8.4.11 The final trim material is cut in 4-foot lengths. This material, along with the rough trim material, is made available to the engineering weight group for to obtain the net weight of the bulkhead.

8.4.12 The final trim is verified using the lines on the labels applied in Step 8.4.2. The labels can then be removed.

8.4.13 The circumferential sizing tool sections (T-7200016) are depressurized. The spreader jacks and tool sections are removed from the inside of the bulkhead and moved to storage. The supports are not removed.

8.4.14 The (T-7204464) circumferential sizing tool and spreader jacks are moved to the inside of the bulkhead. These tools are stored on the inboard area of the work stand (T-7200211). Two vacuum cleaners also are moved onto the inboard platform.



8.4.15 The intercom system is set up to provide communications between the first and second floors and the inside of the tank.

8.5 TRIMMING COMMON BULKHEAD

8.5.1 The toggle jacks are installed on the tool. The adjustment bolts are adjusted so that the distance from the trim of the bulkhead to the top of the support plate on the jacks is 4 inches.

CAUTION

The jacks must be in the fully extended position when the measurements are made.

8.5.2 The common bulkhead assembly is then moved into the vertical assembly building on the transfer table per Specification MJIP-A-14-S11

8.5.3 The spreader bar is attached to the common bulkhead assembly for lifting the assembly into Station 3. The spreader bar cables are connected to the fixtures (8EH-0159) that have previously been installed.

8.5.4 The common bulkhead assembly is oriented so that Position I on the common bulkhead aligns within 1/4 inch with the lower LO₂ bulkhead. The position markers are used to align the bulkheads.

8.5.5 The third floor of the station is lowered and the curtain closed.

8.5.6 The adjustment bolts of the toggle jacks are used to provide equal support at all points. The spreader bar is then disconnected and removed from the station (Figure 8-11).

8.5.7 The space between the top of Cylinder 2 and the third floor is sealed with vinyl sheeting to close out the station.

8.5.8 The adjustment bolts of the toggle jacks are used to bring the lower surface of the bolt ring into a parallel plane with the skate track.

8.5.9 The parallelism of the skate track and the lower flange of the bolt ring is verified at 8 places using a skate with a tooling bar. The 8 places must be parallel within ± 0.030 inch.



Figure 8-11. Adjusting Toggle Jacks

8.5.10 The trim line is scribed 1.150 inches below the lower bolt ring surface at the 4 positions. This allows 0.060 inch for weld shrinkage. Inspection verifies the trim line.

8.5.11 The saw skate is run around the entire perimeter of the skate track to assure that there are no obstructions. The saw is inspected for wear. One toggle jack at a time is lowered to allow the saw to pass. The jack is raised immediately behind the saw.

8.5.12 The height of the saw is set so it cuts below the trim line scribed on the bulkhead.

CAUTION

The saw cut must be below the trim line.

8.5.13 The saw is connected to the vacuum hose and the air supply. The trim cut is then made. This cut should be made in a continuous run with no stops. The toggle jacks are lowered one at a time as the saw moves past them. The shop aid jacks (Figure 8-12) are used in front or behind the saw to reduce the movement when the toggle jacks are lowered. The toggle jacks are raised immediately behind the saw.

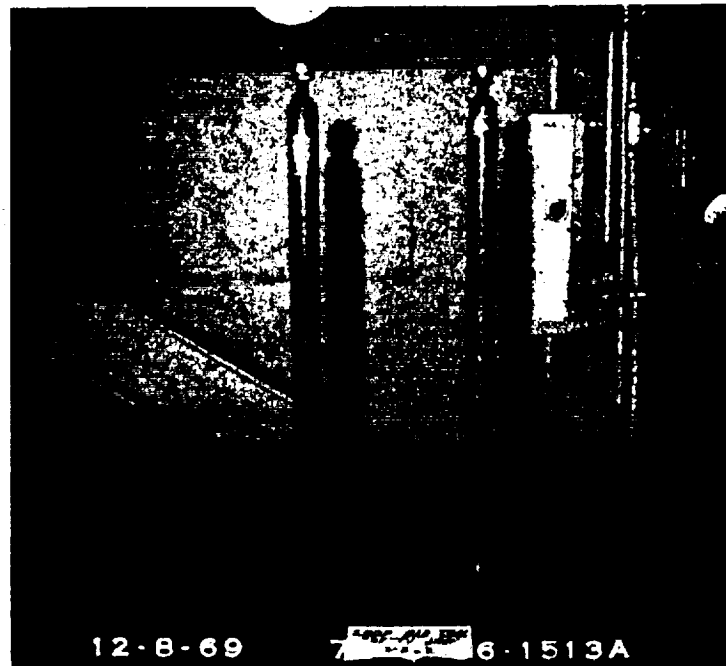


Figure 8-12. Shop Aid Jacks for Use With Saw

8.5.14 The trim material is cut in 4-foot lengths. This material is made available to the engineering weight group for weighing in order to obtain the net weight of the bulkhead.

8.5.15 The final trim is verified by measuring from the lower surface of the bolt ring to the trim line at the 4 positions. A minimum 0.060 inch must be allowed for weld shrinkage.

8.5.16 The chips are vacuumed from the tooling and the inside platform of the LO₂ tank.

8.6 PREPARING FOR WELDING

8.6.1 The riggers move a spreader bar and hydroset into the vertical assembly bulkhead building to support the common bulkhead assembly during the welding operations.

8.6.2 The riggers attach the spreader bar to the adapters (8EH-0159) attached to the bolt ring by means of 8 cables. The overhead crane supports part of the weight of the LO₂ tank assembly during the welding operation by means of the hydroset.



8.6.3 The pi-tape readings of the common and aft LO₂ bulkheads are taken at the trim line per procedures described in Section 1.15.

8.6.4 A prenumbered measuring tape is applied around the aft LO₂ bulkhead approximately 3 inches below the trim line. The tape is marked off in 3-inch increments. The zero mark is at Position I (Figure 8-11).

8.6.5 A piece of Mylar tape is applied on the bolting boss on the inboard side of the common bulkhead. Masking tape is applied over the Mylar tape. The tape is marked in 3-inch increments starting at Position I. The marks must coincide with the marks on the outboard side of the aft LO₂ bulkhead (Figure 8-13).

8.6.6 Inspection takes thickness readings of the weld lands at 3-inch increments. The readings are logged on an ITI sheet in the FALK book.

8.7 VERIFICATION PANELS

8.7.1 Verification plates for the girth weld are run following the procedures described in Section 1.14.

8.8 PREWELD CLEANING

8.8.1 A blower is set up with the exhaust hose projecting into the center of the LO₂ tank for ventilation. The blower is shut off during final cleaning, intermittent tack welding, and continuous tack welding. It can be turned on for the rest of the weld cycle because the weld joint is effectively sealed as the penetration weld is made.

8.8.2 The weld joint is cleaned following procedures described in Section 1.12 (Figure 8-14).

8.8.3 During the precleaning operation the 8 circumferential sizing tool sections are washed using acetone and cheesecloth. A check is made for nicks and burrs on the fingers. A mill file is used to remove any defects and fingers are then washed with acetone and cheesecloth. The sizing tool sections are wrapped with kraft paper until used.

8.8.4 After the precleaning operation the sizing tool sections are installed. Four men lift the sections onto the support chucks (Figure 8-7).

8.8.5 The tool sections are centered on the trim of the aft LO₂ bulkhead by means of the screw adjustment on the lower vacuum chucks. A spirit level placed across the sizing tool sections is used for leveling. The

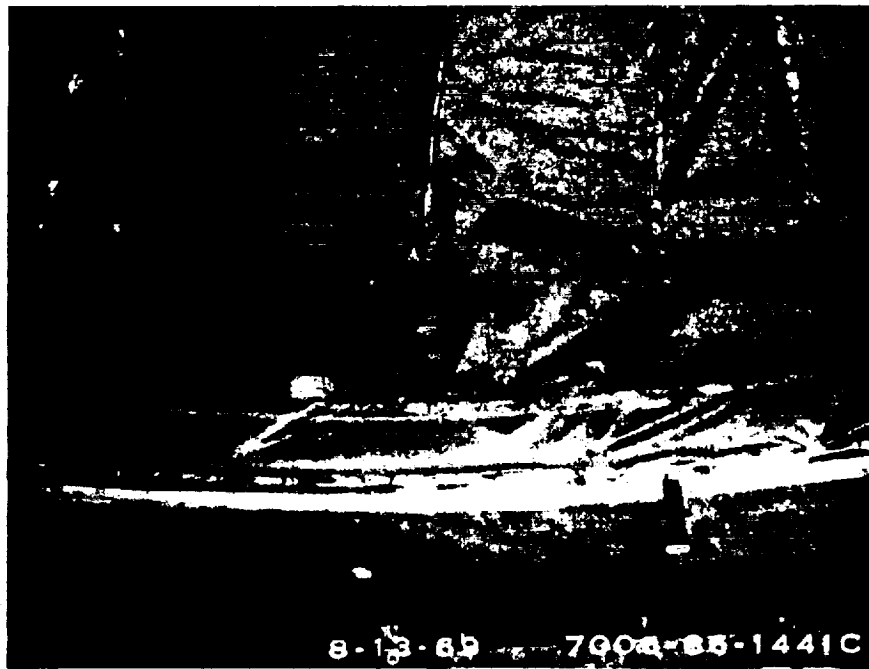


Figure 8-13. Marked Tape Applied Inboard

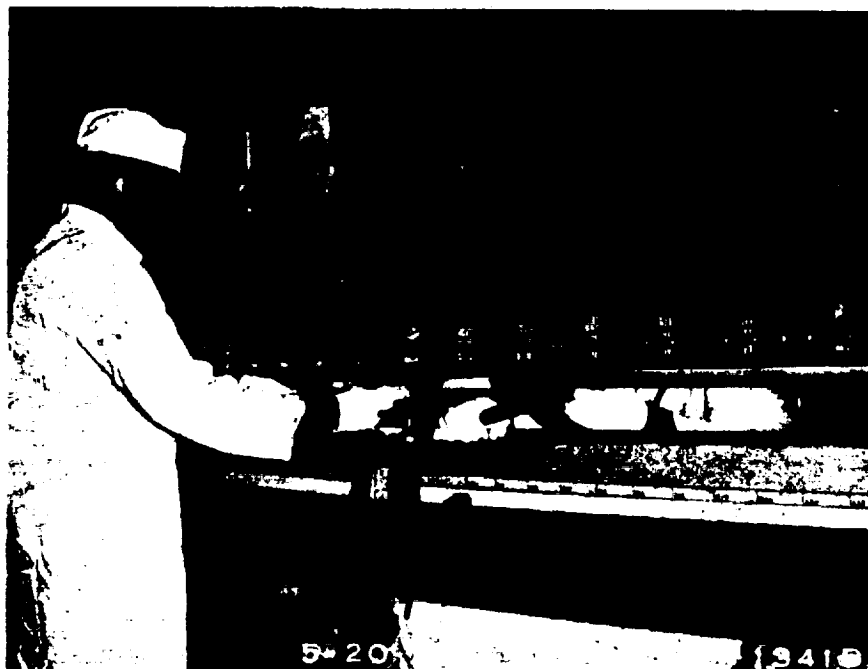


Figure 8-14. Draw-Filing Butt Face



adjustment screw is used to raise or lower the inboard edge of the circumferential sizing tool to level (Figure 8-7).

8.8.6 The common bulkhead is lowered over the circumferential sizing tool to a 1/2-inch gap between the trim edges of the bulkheads. The bulkhead is lowered by lowering the level jacks one at a time. The support pad is screwed down one turn and the jack is gradually lowered as this operation progresses around the bulkhead. The riggers must slack off the bridge crane as the operation proceeds.

8.8.7 The spreader jacks are installed between the sizing tool sections. The jacks pin in at each end with ball lock pins. A turnbuckle is placed between the ends of the sizing tool sections and expanded to facilitate the installation of the last spreader jack. The jack is wrapped in vinyl (Figure 8-15).

8.8.8 The joint is covered on the inboard and outboard sides with aluminum foil until the next shift.

CAUTION

Use only approved tape to secure the foil.

8.9 FINAL WELD CLEANING AND PREPARATION

8.9.1 The aluminum foil is removed from the weld and the joint is prepared as described in Section 1.12.

8.9.2 Two rotational alignment tools (T-7205016) are installed 180 degrees apart. The lower section is clamped to the skate track and the upper section is clamped to the bolting ring (Figure 8-16).

8.9.3 The common bulkhead is lowered by lowering the screws on each support jack with a spanner wrench. The assembly is progressively lowered until a 0.040-inch gap exists at Position I. The riggers slack off on the overhead crane during the lowering operations by operating the hydroset.

8.9.4 Rotational alignment is checked by means of the alignment tool (T-7205017), which is clamped to the skate track and leveled with the builtin spirit level. A tooling bar is projected from a pad on the vertical bar of the alignment tool to the Position I mark on the lower LO₂ bulkhead. The common bulkhead is rotated until the Position I mark lines up with the tool. The common bulkhead can be rotated by means of the screws on top of the alignment tools (T-7205016) (Figure 8-16); alignment must be within 0.030 inch.



Figure 8-15. Spreader Jack Wrapped in Vinyl

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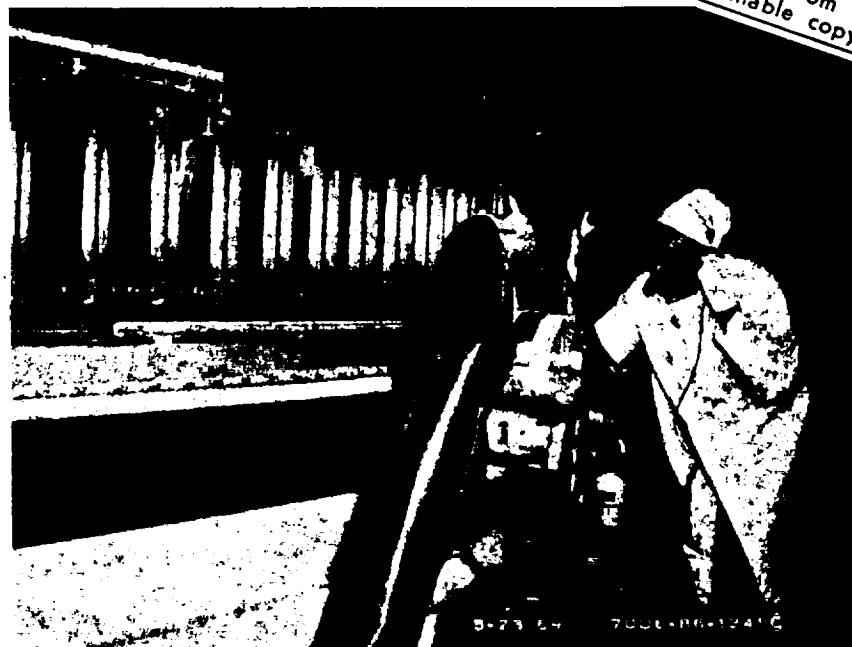


Figure 8-16. Rotational Alignment Tool



8.9.5 During the final cleaning and alignment operations the welders run a bead-on plate to verify the machines for gas, wire, tack, and penetration parameters. The override controls are also placed inside the LO₂ tank.

CAUTION

Make sure the override control switch on the power pack is in the off position during the tack cycle.

8.9.6 The circumferential sizing tool is pressurized to 6000 psi and the rotational alignment rechecked. Inspection verifies the alignment in the FAIR book.

8.10 WELDING OPERATIONS

8.10.1 The offset is checked at Position I. The screws on the circumferential sizing tool are used to adjust the offset if required. The desired offset is 0.010 ± 0.005 inch with the aft LO₂ bulkhead inboard of the common bulkhead (Figure 8-17).

8.10.2 A series of 3 to 6 tack welds is made at Position I. The tacks are 3 inches long on 9-inch centers (Figure 8-18). Inspection verifies the offset after tacking and logs the results on an ITI sheet in the FAIR book (Figure 8-19).

CAUTION

Check the offset prior to each tack. Vacuum the tack area before each tack. Do not touch the weld surface with the vacuum hose.

8.10.3 The offset is checked around the entire circumference. The offset in the rough state must not exceed 0.020 inch.

8.10.4 Tacking is started at Position I and Position III and run around the entire circumference at 9-inch centers (Figure 8-20).

8.10.5 After the tacking is completed the machine parameters are checked for the continuous tack pass.

8.10.6 Offset readings are taken at 3-inch increments (Figure 8-19) and offset entries must be logged on the ITI sheet in the FAIR book.

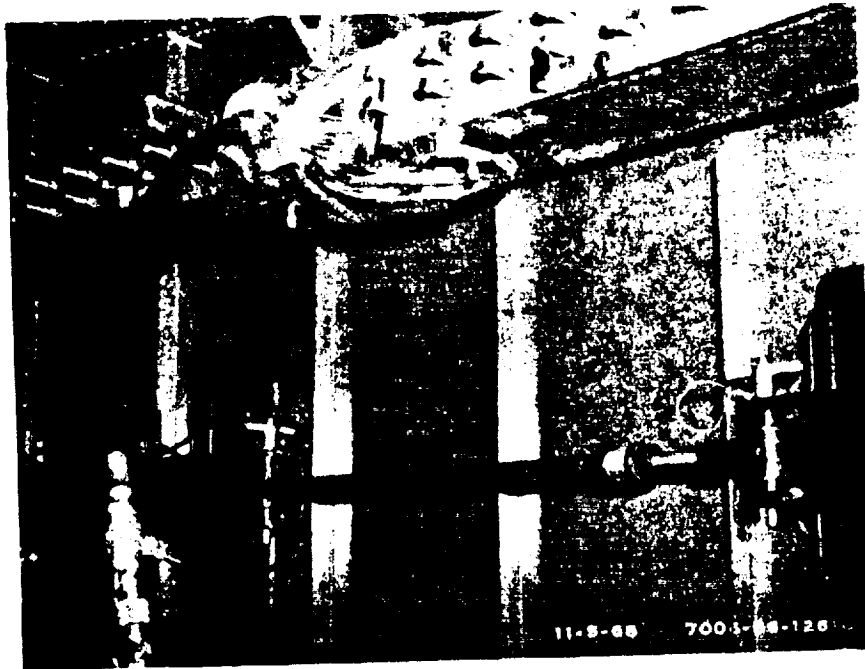


Figure 8-17. Offset Adjustment

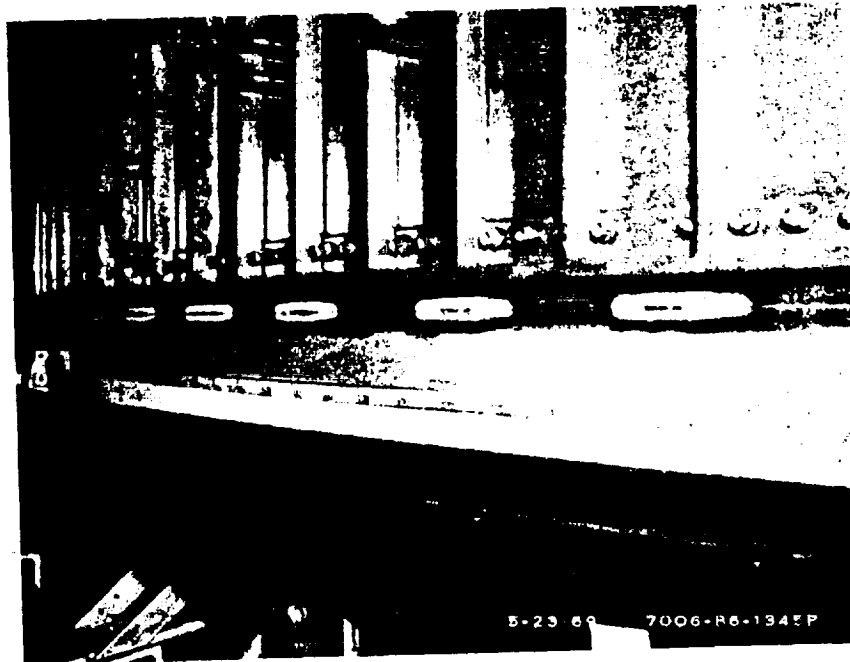


Figure 8-18. Series of Tack Welds

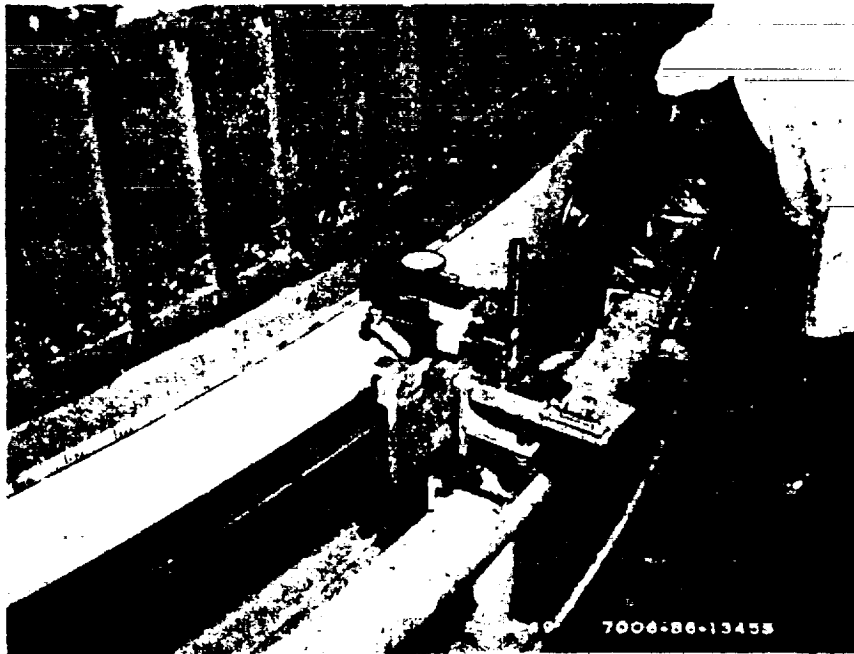


Figure 8-19. Offset Gauge

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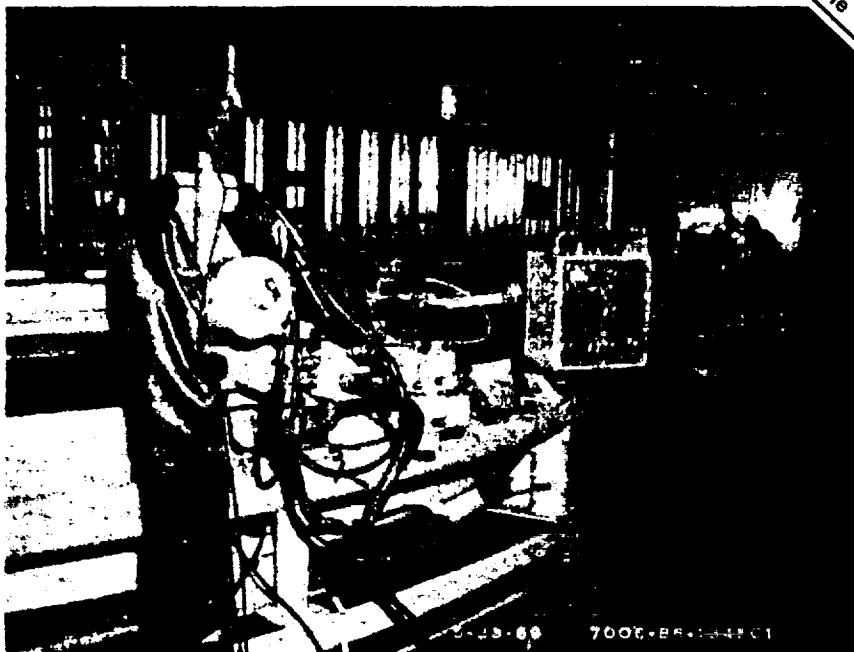


Figure 8-20. Tack Welding Setup



8.10.7 The adjusting screws on the circumferential sizing tool sections are backed off until they are loose, then run back to finger-tight (Figure 8-17).

8.10.8 The sizing tool sections are checked for centering on the joint. If they are not centered, the pressure is dropped, they are recentered, and pressure is returned to 6000 psi.

CAUTION

Do not touch the weld joint during the realignment procedure.

8.10.9 The continuous tack pass is made. A cable tender moves the cables around the LO₂ tank to allow the skate to move freely.

8.10.10 As the arc is extinguished the tailout crater is grooved out to a depth of 0.060 inch using a 1/4-inch ball rotary file. This prevents cracks from propagating.

8.10.11 The soot is brushed from the weld joint using a clean stainless steel rotary or hand brush.

CAUTION

Brush in long strokes in one direction only.

8.10.12 The machine parameters are reset for the penetration pass and verified by the inspectors. The override control switch is turned on. The circumferential sizing tool pressure of 6000 psi is verified. The welders on the outside of the bulkhead check the intercom system with the welders on the inboard side and verify that the inboard crew is ready for the penetration pass.

8.10.13 The two weld heads make the penetration pass, starting 180 degrees apart. The drop-through is controlled by the welder on the inboard side using the override control (Figure 8-21). The cable tenders move the cables around the LO₂ tank.

8.10.14 The end of the penetration pass overlaps the start of the pass by a minimum of 3 inches to assure a good tie-in. The tailout crater is ground out to a depth of 0.060 inch using a 1/4-inch ball rotary file to prevent propagation of cracks.

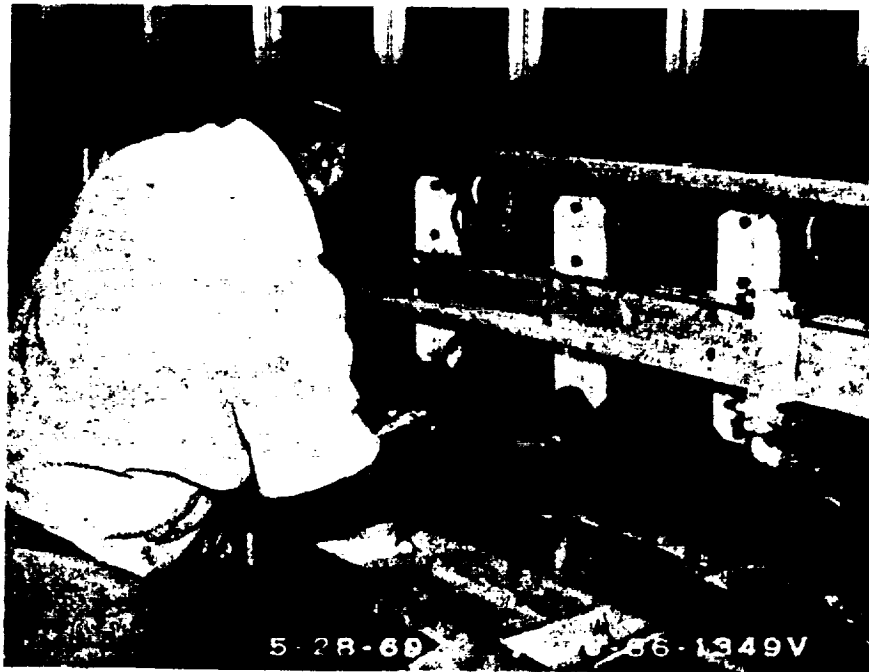


Figure 8-21. Current Override Control

8.10.15 The inboard side is checked for incomplete penetration. If any incomplete penetration areas exist, they are picked up by a supplemental pass per the 971-D-00550 Weld Schedule. This completes the white garment operation.

8.10.16 The circumferential sizing tool pressure is dropped to zero. The 8 spreader jacks are removed and stored on the inboard platform. The 8 sizing tool sections then are removed and also stored on the inboard platform.



Do not stack the sizing tool sections in one area. Distribute them around the inside edge of the platform.

8.10.17 The drop-through is inspected for undercut, insufficient penetration, and folds per Specification MA0107-016. Inspection verifies the operation in the FAIR book.



8.10.18 Three or four weld shavers are used to mill the drop-through bead to a height of 0.010 to 0.015 inch above the parent metal (Figure 8-22).

CAUTION

Do not cut into the parent metal.

8.10.19 Bear-Tex wheels in air motors are used to polish the inboard or drop-through side of the weld (Figure 8-23). Long strokes are used, with no pauses in one area, which will cause low spots.

CAUTION

Do not use the Bear-Tex wheel across the weld or at an angle.

8.10.20 A stainless steel rotary or hard brush is used to remove the soot from the outboard side of the penetration pass.

8.10.21 The outboard side of the weld is inspected for folds, etc., which can be blended out with a rotary file prior to X ray. The outboard and inboard sides of the weld are wiped with cheesecloth dampened with acetone.

8.10.22 The X-ray technicians X-ray the penetration pass and read out the film. Triangulation shots are made for all areas out of specification. Manufacturing supervision and the weld engineer determine which defects should be reworked prior to the cover passes on the weld. A Manufacturing request (Form 0121-S) is filled out requesting planning tickets for in-process rework.

8.10.23 Defective areas are repaired as described in Section 10.

8.10.24 The circumferential sizing tool is installed and pressurized to 6000 psi. The parameters on the weld packs are programmed for the cover passes per the Weld Schedule. A verification bead-on pass is made to check the machine operation. The override control is turned off.

8.10.25 The following operations require white garments. The outboard side of the weld is wiped with cheesecloth dampened with acetone to remove any tape residue or fingerprints left from the X-ray operation.



Figure 8-22. Milling Weld Bead



Figure 8-23. Abrading Weld Bead With Bear-Tex Wheel



8.10.26 The outboard side of the weld is brushed with clean stainless hand or rotary brushes.

CAUTION

Brush in long strokes in one direction only. Do not brush across the weld.

8.10.27 The dust is vacuum-cleaned from the weld joint.

CAUTION

Do not touch the weld surface with the vacuum hose.

8.10.28 The first cover pass is made using two weld machines 180 degrees apart. The welder must assure that the edge of the cover pass covers the bottom edge of the penetration pass. The tailout of one machine must overlap the start of the second machine a minimum of 6 inches before sequencing out. The cable tenders handle the cables around the LO₂ tank per established procedures. The tailout crater is ground out to a depth of 0.060 inch using a 1/4-inch ball rotary file. The first cover pass is brushed using a clean stainless rotary or hand brush.

8.10.29 The second cover pass is made. The cover pass must cover the upper edge of the penetration pass. The tailout of the first pass overlaps the start of the second pass a minimum of 6 inches. The tailout cracks are ground out to a depth of 0.060 inch with a 1/4-inch ball rotary file. The second cover pass is wire brushed using stainless wire brushes.

8.10.30 The cover pass is inspected for areas with a lack of fill. If lack-of-fill areas exceed the specification requirements, supplementary weld passes are made per the 917-D-00550 Weld Schedule.

8.10.31 The pressure on the circumferential sizing tool is lowered and the sections removed. Three or four weld shavers are used to mill the cover passes to a height of 0.010 to 0.015 inch.

CAUTION

Do not touch parent metal with the mills.



8.10.32 The cover pass weld is abraded with Bear-TeX using a rotary wheel.

CAUTION

Do not abrade at an angle to the bead. Use long strokes only.

8.11 POST-WELD OPERATIONS

8.11.1 Technicians X-ray the entire weld. The film is read out and triangulation shots are made of any areas out of specification. Rework, if required, is done by the rework process or MR action.

8.11.2 After the X rays are completed, fluorescent penetrant inspection is performed on the inboard and outboard sides of the entire weld. Manufacturing personnel assist by blending out defects which do not lie below the surface of the parent material thickness. Any out-of-specification defects which cannot be reworked are submitted to Material Review.

8.11.3 Inspection verifies the X-ray and penetrant operations in the FAIR book.

8.11.4 The weld land is Chem-filmed on the inboard and outboard side by personnel certified in manual chemical operations.

8.11.5 When the Chem-film has dried a minimum of 12 hours, the area is covered with approved black tape or strippable vinyl coating.

8.11.6 The FAIR book is recapped in preparation for mating the LO₂ tank to the static firing skirt.



9.0 CYLINDER 3 TO CYLINDER 2 CLOSEOUT WELD

9.1 GENERAL DESCRIPTION

9.1.1 The techniques and procedures utilized in the welding of Cylinder 2 to Cylinder 3 of the LH₂ tank are described in this section. This is the last circumferential weld and completes the buildup of the LH₂ tank. The operation is performed in Station 1 of the vertical assembly building. Cylinder 2, Cylinder 1, and the complete LO₂ tank, mated with the simulated aft skirt, are mounted on the support tool (T-7204383). The upper LH₂ tank sub-assembly consisting of Cylinders 3 through 6 and the LH₂ bulkhead are joined to Cylinder 2 by a circumferential weld. The weld joint offset is controlled by an internal circumferential sizing tool (T-7204464).

9.1.2 Reference documents applicable to this procedure are as follows:

V7-332002	LH ₂ Tank Assembly
V7-333002	LO ₂ Tank Assembly
MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-film
971-D-00265	Weld Schedule
MHP-A-18-S-II	Lift Upper LH ₂ Tank Assembly Onto the LO ₂ Tank Assembly
MHP-E-20-S-II	Install T-7204234 Work Platform on Common Bulkhead
MHP-E-92-S-II	Position 8EH-0035 Personnel Chute and/or 8EH-0760 Basket to LH ₂ Tank, VAB
TO5-556-0025	Work Platform - LH ₂ Tank
TO5-556-0027	Offset Measuring Tool Circumferential Weld
PRO-565-014	Circumferential Weld, Cylinder 2 to Cylinder 3, Closeout Weld

9.2 LOADING THE STATION

9.2.1 Floors 1 through 6 of station 1 are raised to permit access. The stage transfer dolly, supporting the support tool (T-7204383) and the lower



tank-skirt subassembly, is moved from the facility transport dolly into the weld station. Movement of the stage dolly is provided by the internal power system of the dolly.

9.2.2 The sections of Floors No. 2 and No. 3 are then lowered. The first- and second-floor curtains are closed. The distance from the tank wall to the third-floor opening is checked at stage positions No. 2 and No. 4. The stage dolly is moved to equalize the distances.

9.2.3 The tool supporting the lower stage subassembly is leveled employing jacks attached to the stage dolly. The level plane is verified utilizing optical equipment and white-faced scales positioned on leveling pins in the tool at 4 places.

9.2.4 The contoured debris barriers (eyebrows) are installed around the cylinder at the third-floor level starting at Position I, as marked on the floor and the contoured board (Figure 9-1).

9.3 TOOLING INSTALLATION

9.3.1 The internal work platforms (T-7204234 and T-7200213) are installed on the common bulkhead. The overhead crane is employed in the handling and positioning of the work platforms as defined by Specification MHP-E-20-S-II (Figure 9-2).

9.3.2 The edges of the pads, steps, and cracks in the platform are sealed with tape. A vinyl seal is installed from the platform to the pads, with its edges taped down (Figure 9-3).

9.3.3 The sheet metal chip catcher is laid on the web of the top frame of Cylinder 2. Aluminum tape is used to seal the edges and joints (Figure 9-4).

9.3.4 A vinyl sheet extending from the internal platform to the upper frame of Cylinder 2 is laid around the entire tank and taped in place.

9.3.5 The vacuum chucks which secure the tooling to the skin surfaces of the tank walls are activated by the facility vacuum system. The vacuum manifold for the inboard chucks is connected to the vacuum system by a line passing through one fuel outlet in Cylinder 2 (Figure 9-5). The outboard manifold is laid around the cylinder on the third floor (Figure 9-1).

9.3.6 The hydraulic system employed in pressurizing the circumferential sizing tool is pressure-tested to 6000 psi and checked for leaks prior to use. The hydraulic line connecting the internal manifold and multiple lines passes through a fuel outlet to the hydraulic system placed outside of the tank at the second-floor level (Figure 9-6).

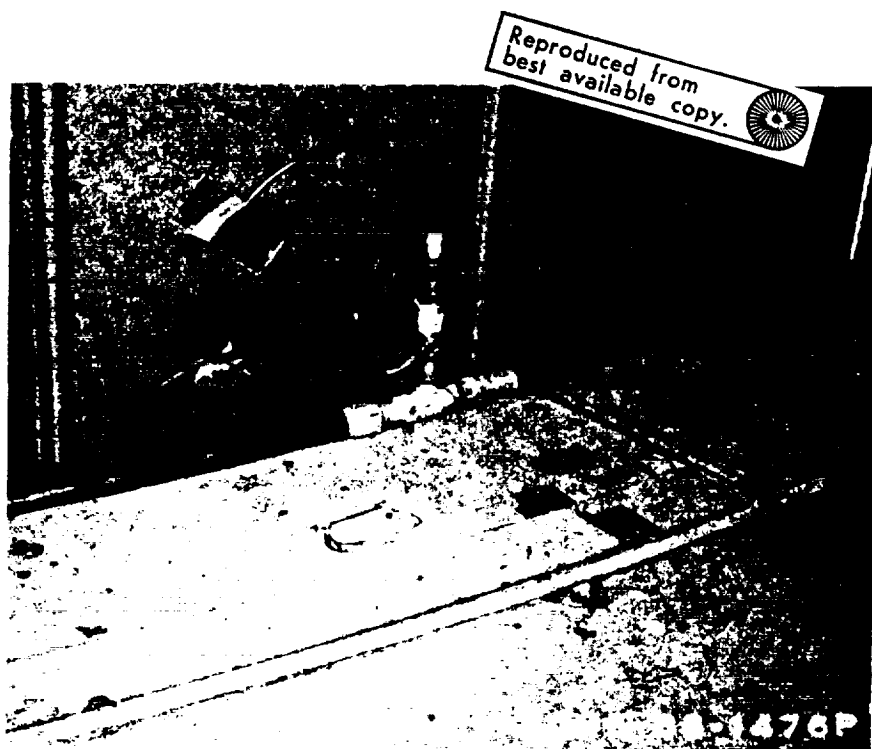


Figure 9-1. Eyebrow Installation and Outboard Vacuum Lines

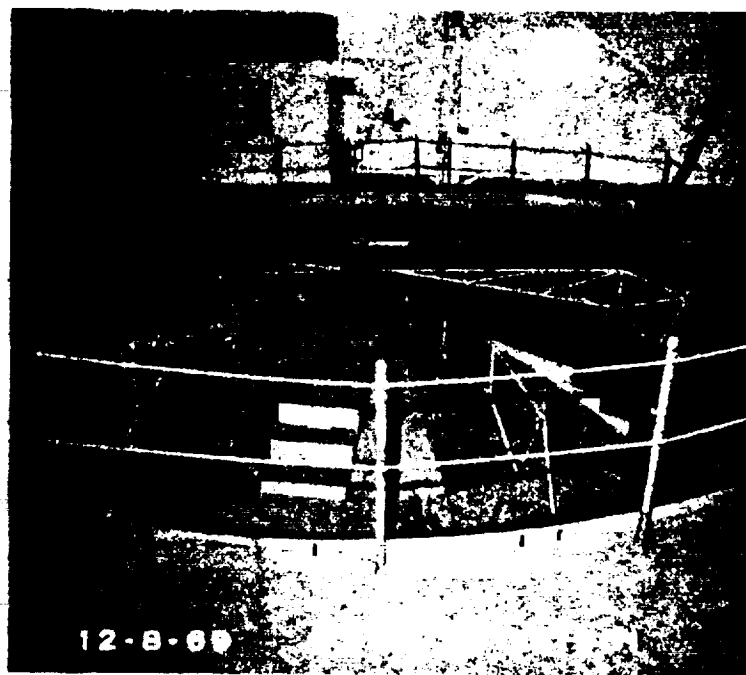


Figure 9-2. Internal Work Platform

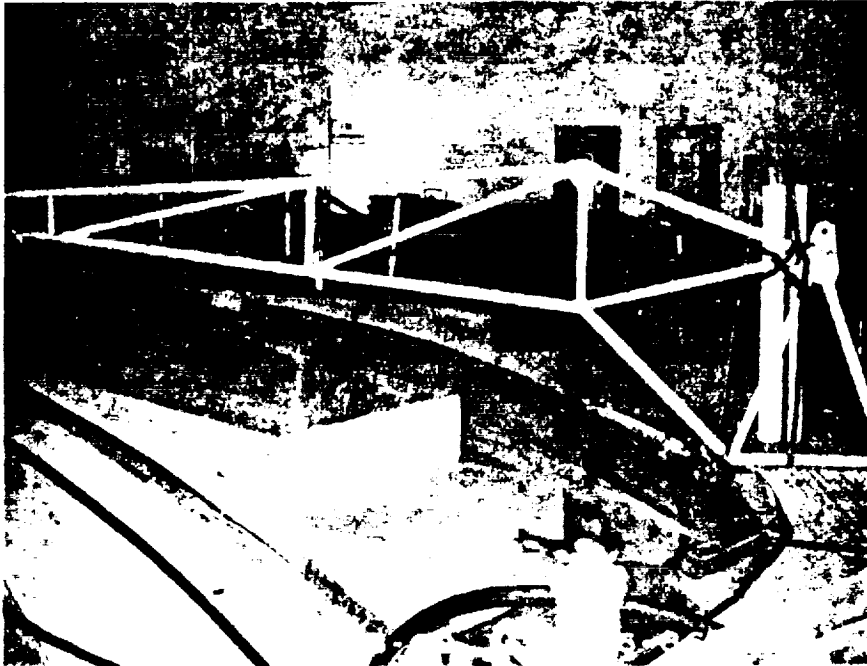


Figure 9-3. Installation of Vinyl Seal

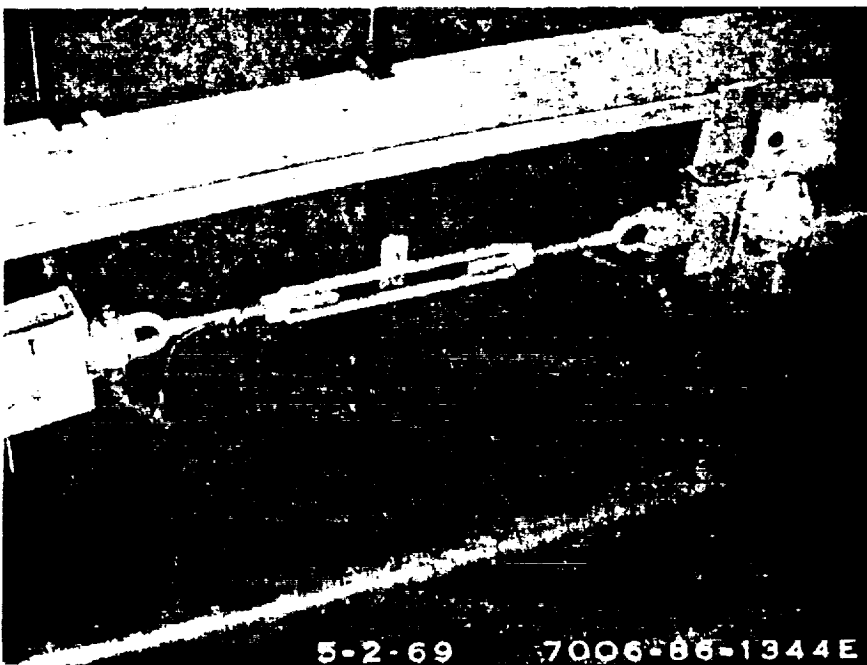


Figure 9-4. Inboard Chip Catcher Installation

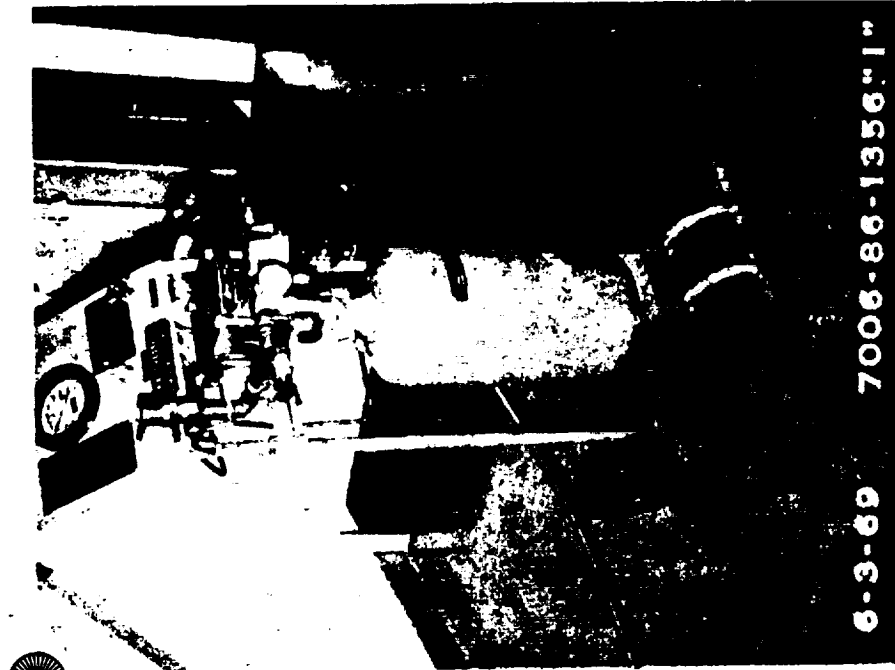


Figure 9-6. Hydraulic Pump

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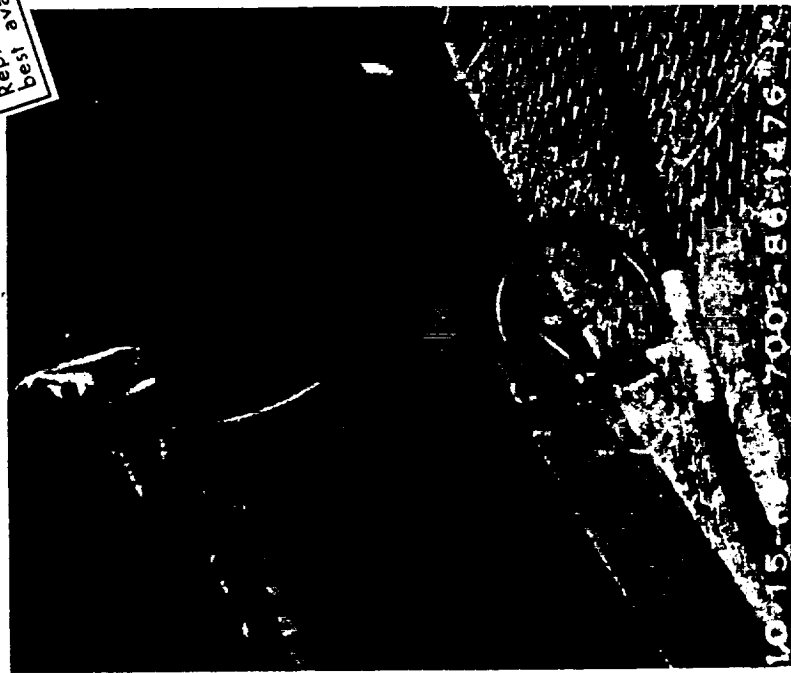


Figure 9-5. Vacuum and Hydraulic Line Installation



9.3.7 An air blower with a 6-inch outlet is positioned on the second floor. A hose is installed between the fill and drain outlet of the LH₂ tank and the blower. The blower provides air circulation into the tank.

9.3.8 The air and electric power lines are placed into the tank through the fuel outlet at the second-floor level. Six encapsulated fluorescent lamps are installed inside of the tank and secured to the rails (Figure 9-3).

CAUTION

Use only approved electrical lines with no exposed metal connectors.

9.3.9 The vacuum chucks of the outboard skate track tool (T-7200039) are wiped clean. The tool sections are installed employing hangers to hold the track sections parallel to the cylinder edge. The track sections are joined by the hex-head screws in the splice plates (Figures 9-7 and 9-8).

9.3.10 The set screws in the skate track over the vacuum chuck brackets are adjusted inboard approximately 1/4 inch to maintain uniform spacing between the track and cylinder wall (Figure 9-9).

9.3.11 The vacuum lines from the main pump to the chucks are connected and the vacuum drawn. Vacuum leaks can be minimized by gently tapping the vacuum chuck brackets (Figure 9-10).

9.3.12 The skate track hangers are removed. The set screws used to adjust the vacuum chuck brackets are removed to permit unrestrained tank skin expansion. The skate track must be parallel to the top edge of the cylinder within ± 0.030 inch. Using a hanger block as a gauge, tap the skate track gently with a plastic-tipped mallet to achieve the parallel tolerance.

9.3.13 The 2-inch lengths of Mylar tape used for positioning the internal vacuum support tooling are placed with the lower edge of the tape 8 inches below the edge of the cylinder. Three pieces of tape are placed on each cylinder quarter-panel, one in the center of each panel and one piece approximately 1 foot on each side of the vertical weld.

CAUTION

Use only tape approved for use on the S-II stage.

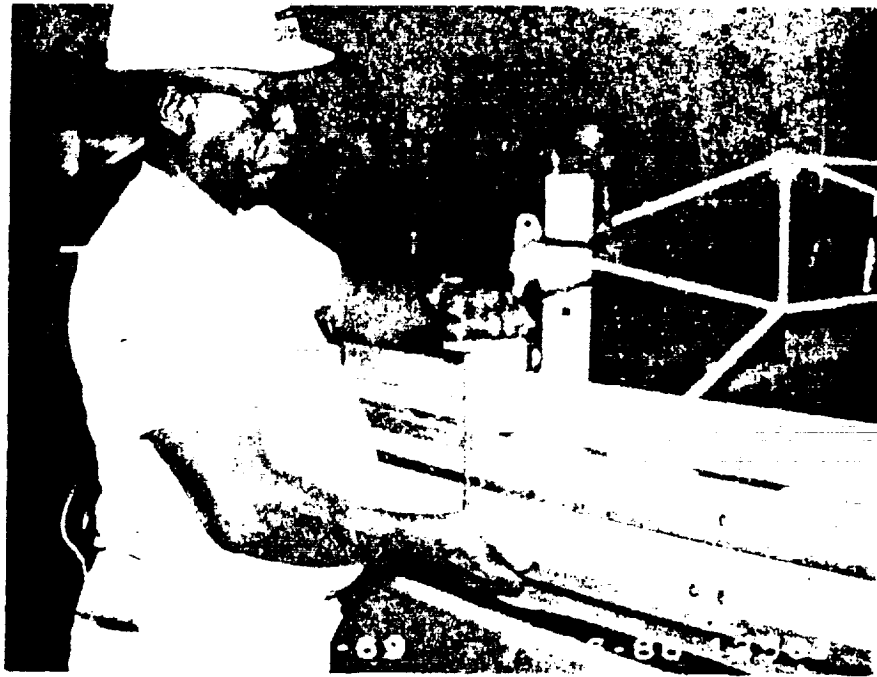


Figure 9-7. Skate Track Hangers Installed

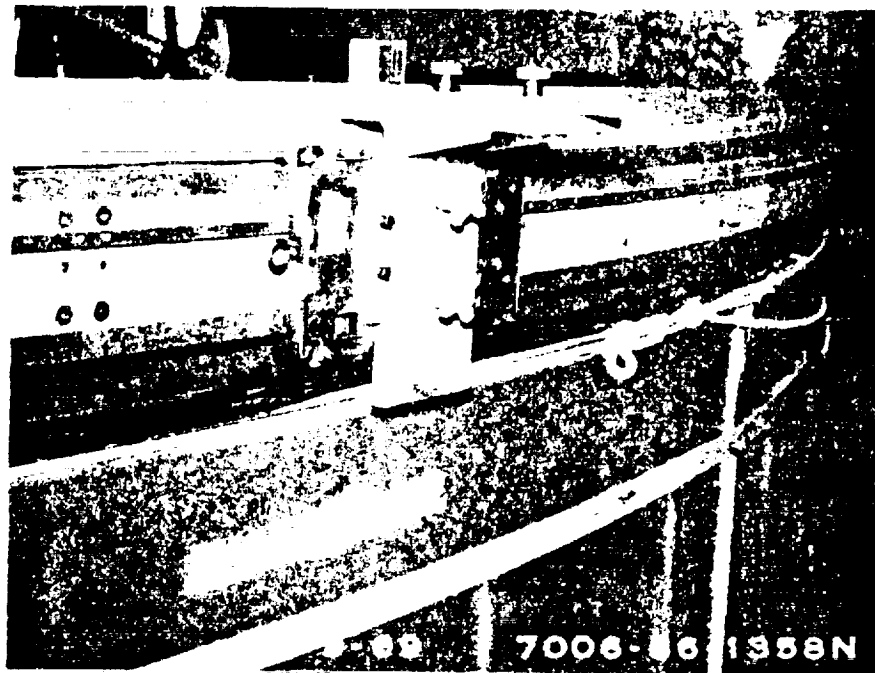


Figure 9-8. Skate Track Section Joint



Figure 9-9. Set Screw Installation

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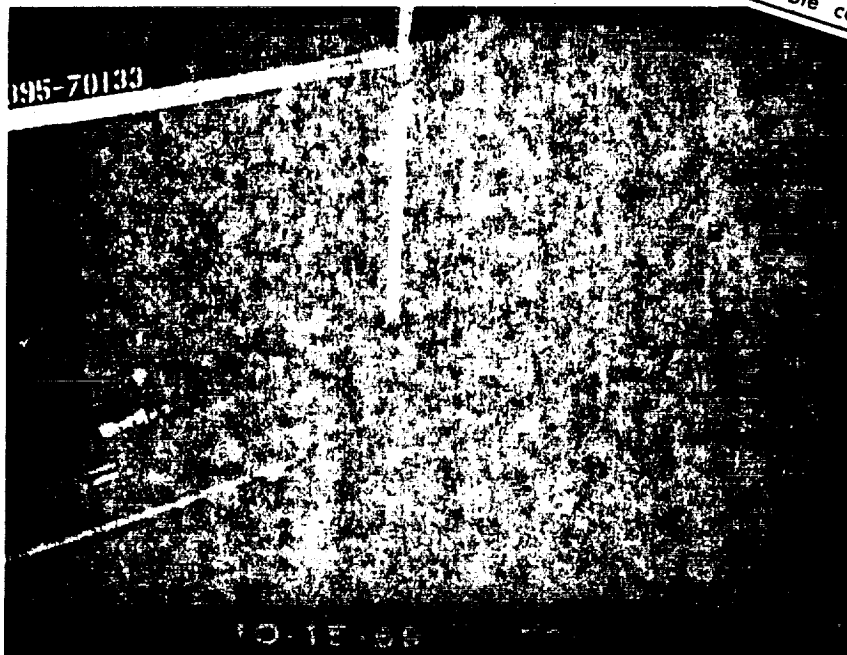


Figure 9-10. Vacuum Line Connection

9.3.14 The lower vacuum chucks of the support tool are dusted, using cheesecloth dampened with acetone.

CAUTION

Acetone is flammable. Use only approved containers and plastic bottles. Do not use acetone in open pans.

9.3.15 The lower vacuum chucks are located at the inboard wall of Cylinder 2, one set at a time. The top edge of the vacuum chucks must be kept level to the bottom edge of the Mylar tapes, 8 inches below the butt edge of the cylinder. The first chucks on the ends of the tool must be centered between the first and second vertical grids, adjacent to the vertical welds on the cylinder. Three men are required to position the chucks (Figure 9-11). As the chucks are aligned to the cylinder, the vacuum line from the chucks is connected to the vacuum manifold and the line opened to vacuum to secure the chuck. The chucks are tapped lightly to help them seat and prevent vacuum leaks (Figure 9-12). The chucks are aligned around the cylinder and the system is checked for vacuum leaks.

9.3.16 The spreader links between the ends of the 8 vacuum chucks are installed. The ends of the spreaders are attached to the chuck frame by means of a ball lock pin in each end (Figure 9-13). The 8 spreader links are expanded by hand. This forms a full circle of the vacuum chucks and helps to support the chucks in case the vacuum supply fails (Figure 9-14).

9.3.17 The 8 circumferential sizing tools and two vacuum cleaners are moved to the inside of the cylinder. The intercom systems and phones are set up, inboard on the third floor and on the second, third, and sixth floors on the outboard side of the assembly.

9.4 STAGE AND STATION PREPARATION

9.4.1 The numbered strip tape is applied below the weld land area on the outboard side of the tank. The strip is numbered every 3 inches starting with zero. When applying the strip, the zero mark is located at Position I on Cylinder 2. Only approved tape may be used to hold the numbered strip to the cylinder (Figure 9-8).

9.4.2 Inspection will check the thickness of the Cylinder 2 weld land at each 3-inch increment. The measurements, taken with a micrometer, will be logged on an ITI-SB121 form (Figure 9-15). Any out-of-tolerance areas



Figure 9-11. Positioning Lower Vacuum Chucks

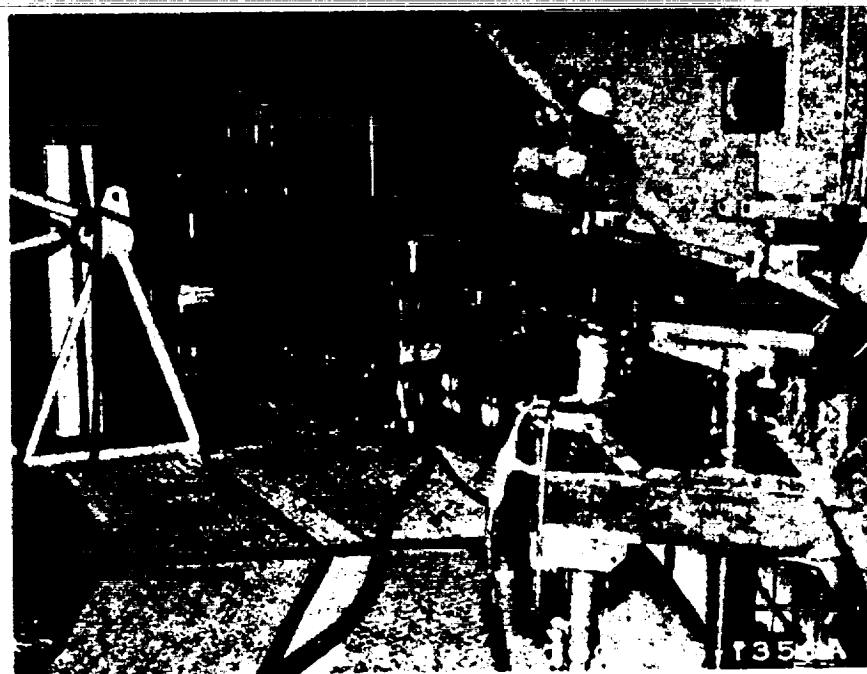


Figure 9-12. Lower Vacuum Chuck Installation

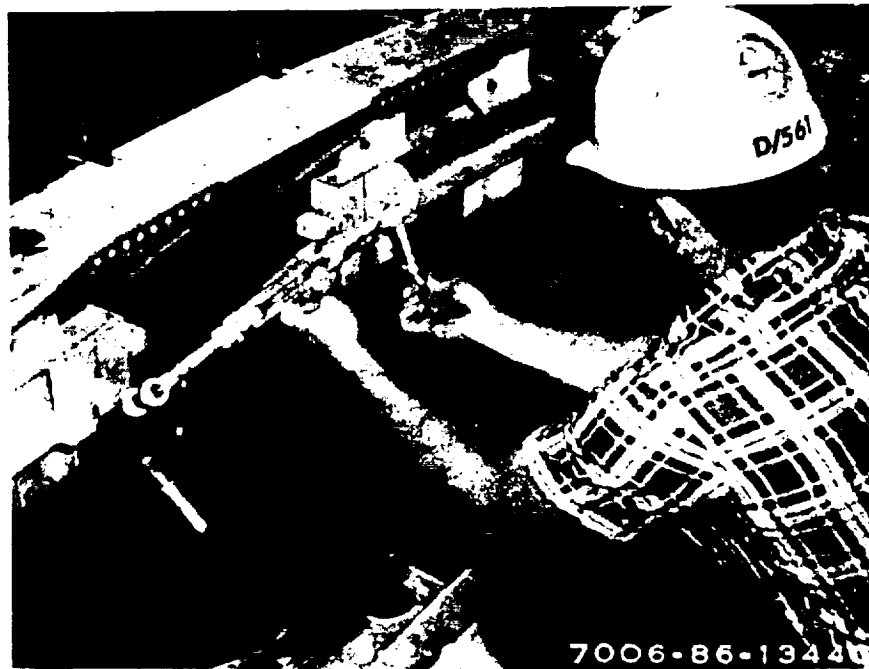


Figure 9-13. Ball Lock Pin Installation

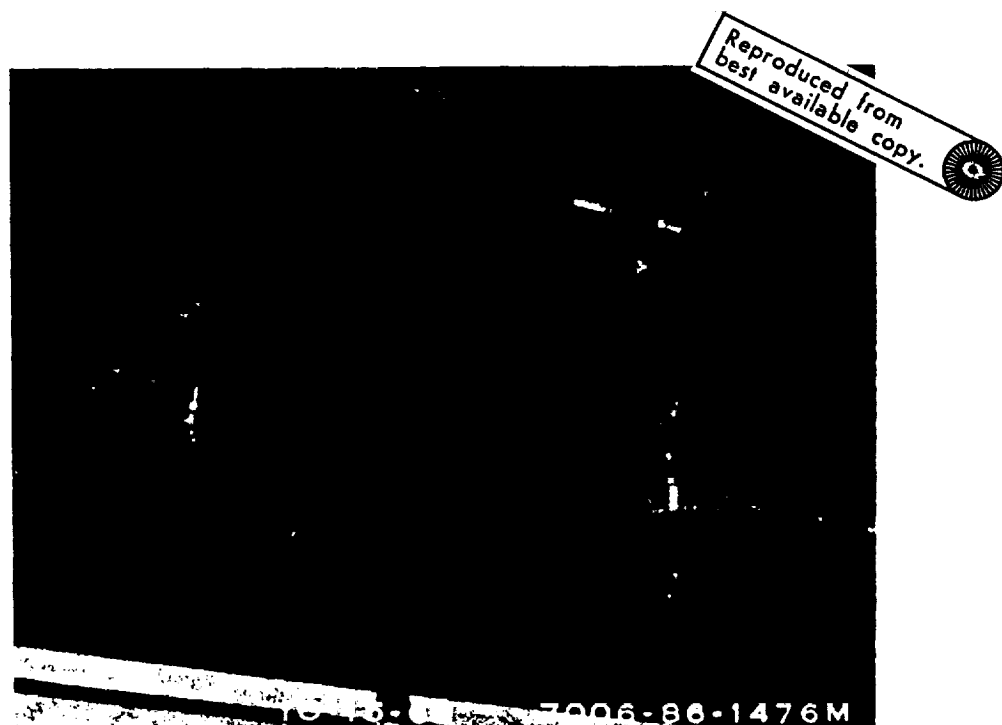


Figure 9-14. Spreader Link Installation



which are undersize will be submitted to Material Review for disposition. Oversize areas will be draw-filed to tolerance. The ITI form is logged in the FAIR book.

9.4.3 While the Cylinder 3 assembly is on the tool support in Station 3, a numbered tape strip identical to the one applied on Cylinder 2 is applied above the weld land of Cylinder 3. Cylinder 3 is checked for thickness as previously defined for Cylinder 2. There will be 10 areas at the supports which will not be accessible. These areas are to be by passed.

9.4.4 All inboard frames of the Cylinder 3 assembly in Station 4 must be checked to make sure there are no tools, parts, etc., on them. The floor boards on the internal platform of the support tool in Station 3 are retracted. The third floor of Station 1 is wet-mopped and all bench tops, bin tops, and exposed beams are dusted. The operation of the shoe brush in the airlock entrance to the weld station is checked.

9.4.5 The Cylinder 3 assembly is raised from the support tool and moved to Station 1 per Specification MHP-A-18-S-II at the start of the weld preparation shift (Figure 9-16). The spreader bar (8EH-0226) with the walkway must be used to provide access during tank entry.

9.4.6 Cylinder 3 is centered over Cylinder 2. Cylinder 3 is lowered so that its lower edge is about 18 inches above Cylinder 2. The rotational alignment of the two cylinders is achieved by aligning Position I or the systems tunnel attachment holes. Rotation need only be held within $\pm 1/2$ inch at this time. The systems tunnel is approximately 6 feet counterclockwise from Position I. Four spacer blocks are installed using plastic coated C clamps (Figure 9-17).

CAUTION

Cover the clean spacer blocks with aluminum foil.

9.4.7 The fourth, fifth, and sixth floors are lowered, the curtains on the third, fourth, and fifth floors are closed, and a vinyl or kraft paper seal is installed from the fourth floor to the cylinder wall. Sufficient material is allowed so the cylinder can be raised and lowered during preweld operations (Figure 9-18).

9.4.8 The thickness of Cylinder 3 in the areas previously skipped is checked. Inspection will then log the pi-tape readings of the Cylinder 2 and 3 circumferential weld lands in the FAIR book. These readings are those



Figure 9-15. Weld Land Thickness Verification

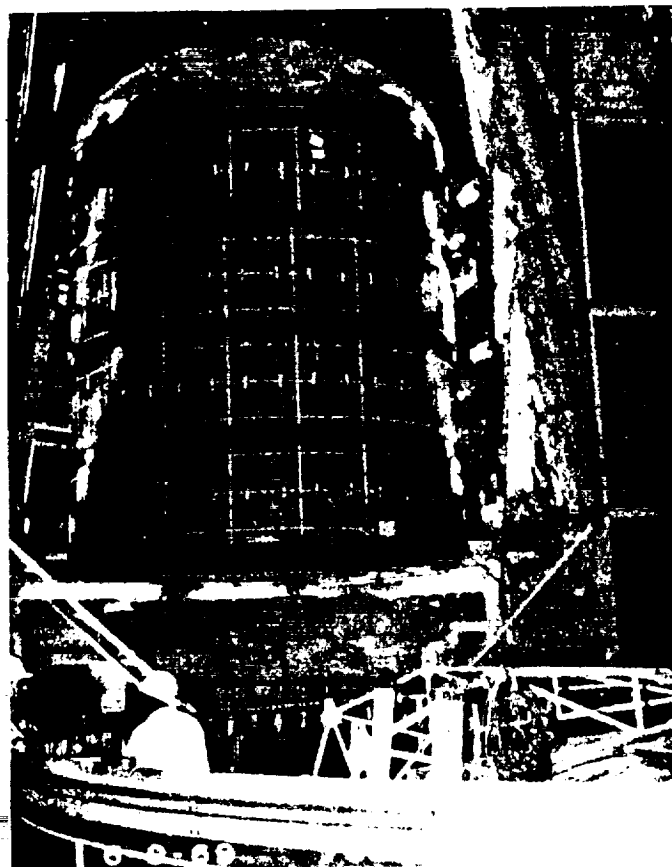


Figure 9-16. Moving Assembly to Station 1



Figure 9-18. Fourth Floor-Cylinder Seal

Figure 9-17. Spacer Block Installation



previously taken during cylinder buildup and after the cylinders were trimmed. Any dimensions out of tolerance will be submitted to MR for disposition.

9.4.9 One-inch Mylar tape is applied to the inside of Cylinder 3 two inches above the lower horizontal rib. The tape is applied between the vertical ribs around the entire circumference. Apply masking tape over the Mylar tape. Mark the inboard tape in 3-inch increments starting with zero at Position 1. The inboard marks are checked with the outboard marks on Cylinder 2 for any mismatch in location.

CAUTION

Do not apply masking tape to the cylinder wall. Apply only over the Mylar tape.

9.4.10 The stringer end protectors are installed on Cylinders 2 and 3 for protection during installation of the circumferential sizing tool and during cleaning of the weld joint.

9.4.11 The temperature in the weld station should be 76 F minimum. The relative humidigraph reading on the third floor of the weld station should not exceed 50 percent humidity. If the temperature or humidity exceeds the allowable tolerances, call Maintenance to correct the condition.

9.4.12 The weld station is vacuum-cleaned and wiped. The second floor air blower is not turned on because the draft will contaminate the weld joint during cleaning and welding.

9.4.13 The tank entry hook is lowered through the LH₂ manhole into the tank to the third-floor level. A bosun's chair is attached and raised to the sixth-floor level. A rope is installed over a pulley hanging from the overhead bridge; this is used as a lifeline in case of an emergency.

9.5 VERIFICATION PANELS

9.5.1 The verification panels are run prior to preweld cleaning as described in Section 1.14.



9.6 PREWELD CLEANING

9.6.1 Preweld cleaning operations will be performed as described in Section 1.12.

CAUTION

Only personnel qualified for preweld cleaning are to clean the weld joint area.

9.6.2 During the precleaning operations, the 8 circumferential sizing tools are washed down with acetone using clean cheesecloth. The circumferential sizing tools are checked for nicks and burrs on the fingers which come into contact with the weld lands. The defects are draw-filed with a mill file and washed with acetone and clean cheesecloth. The circumferential sizing tools are wrapped with kraft paper and stored on the third floor outside of the cylinder.

9.7 TOOLING INSTALLATION

9.7.1 Tooling providing support for the circumferential sizing tool segments is installed as shown in Figure 9-19. There are 16 supports, two for each segment. The height of the support (K) is adjusted to 2 inches below the top edge of Cylinder 2 using the wingnut (L). The center T-supports are installed by hooking the support over the top flange of the channel cross member. Set screws are adjusted to level the top support. Wingnuts adjust the height to 2 inches below the top of Cylinder 2.

9.7.2 Access to the inside of the tank at this time is made by climbing through the open joint with the lower cylinder edge covered with aluminum foil. Five men with Confined Space Entry certificates will be assigned to the inboard operation. A safety harness is put in the tank for each man assigned. This is in preparation for the tank entry which starts when the joint is closed. The crew is briefed by the leadman or supervisor on the work effort and safety practices. The intercom system is checked.

9.7.3 The kraft paper is removed from the circumferential sizing tool (T-7204464). With the lights turned off, cleanliness of the sizing tools is checked using a black light. The circumferential sizing tools are heavy, requiring five men outboard and five inboard to handle them. The five men on the outboard side lift the tools and pass them through the open weld joint

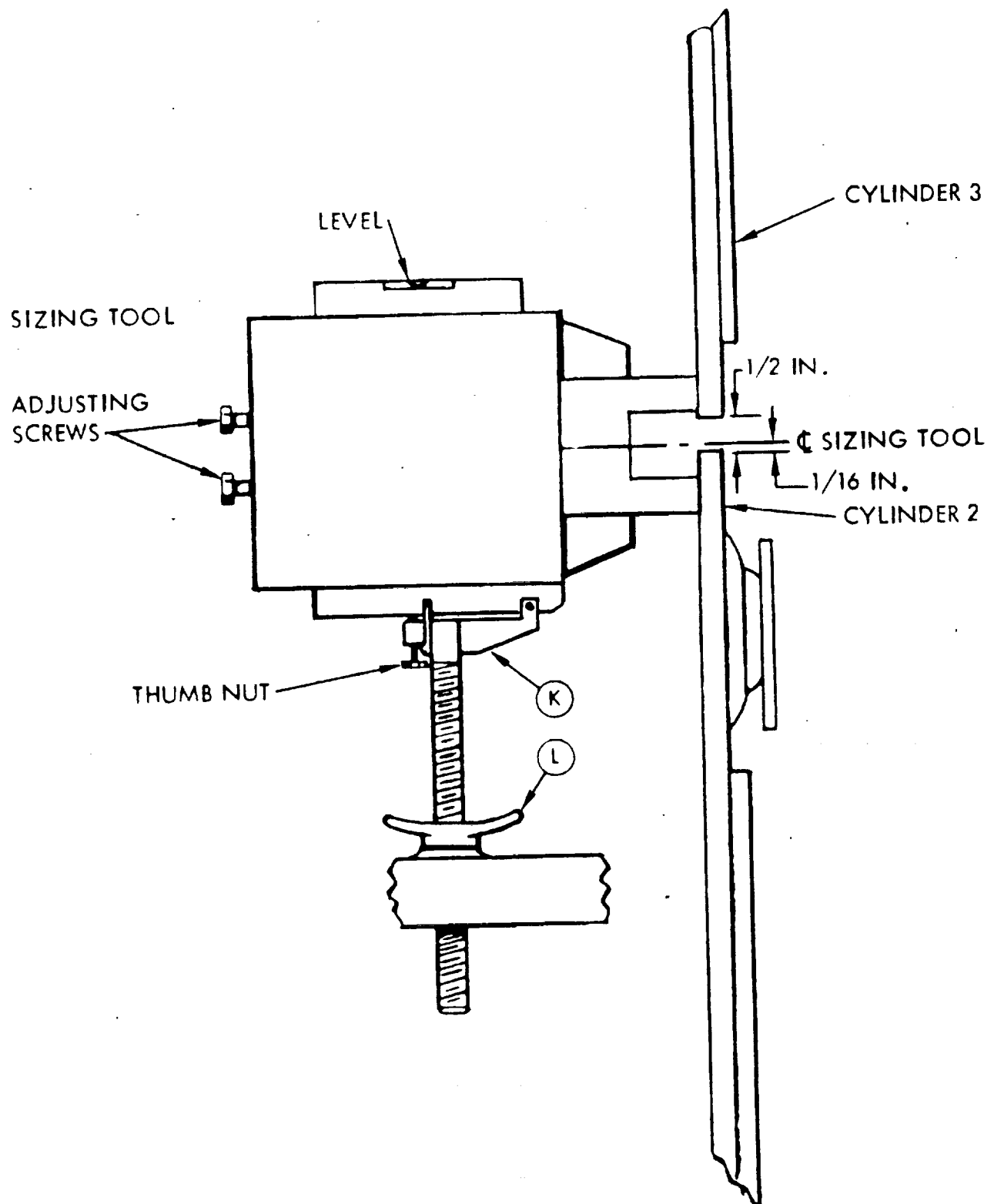


Figure 9-19. Height Adjustment



to the inboard crew. The tools are coded on each end, designating their relationship.

CAUTION

Do not allow the tools to touch the clean weld joint.

9.7.4 The spreader jacks (T-7204464) are wrapped in vinyl bags. This is to provide protection if the hydraulic system develops leaks. The jacks are stored on the floor of the work platform inside of the cylinder.

9.8 CONFINED SPACE ENTRY

9.8.1 A tank monitor is assigned to the sixth floor. He prepares a Confined Space Entry Permit (Form 997-Q), including a roster of the crew in the tank. He maintains contact with them through the intercom system. A fireman, assigned by Protective Services, moves a cabinet with emergency equipment to the sixth floor. The fireman is the Tank Entry Controller and assures that safety conditions are maintained. A full crew of riggers and a move conductor are used during the lowering of the cylinders and tank entry operations. During the preweld cleaning operation only a standby crew is needed. The completed Confined Space Entry Permit must be signed by the Tank Entry Controller, supervisor, and the System Safety representative and posted in a conspicuous location on the sixth floor. The bosun's chair is lowered into the tank to the third-floor level. When the cylinders are lowered, closing the joint, the tank is considered a confined space and all associated safety practices must be followed. The tank monitor will keep an accurate roster of men in the tank at all times.

9.9 PREWELD PREPARATION

9.9.1 The upper LH₂ tank subassembly is suspended on the overhead crane. The four spacer blocks between Cylinders 3 and 2 are removed. The cylinder is balanced employing sand-filled bags positioned on the inboard frame.

9.9.2 The upper cylinder assembly is lowered to within 1/2 inch of Cylinder 2 using the overhead crane. A hydroset attached to the crane and tank-handling fixture lowers the tank precisely as specified in MHP-A-18-S-II until joint contact is achieved.

9.9.3 The spreader jacks (T-7204464) are installed between the circumferential sizing tools at 8 places. Ball lock pins secure the jacks in position. Turnbuckles are employed to expand the end distance between the



circumferential sizing tools and permit easy installation of the jacks. Caution must be exercised to prevent contacting the cleaned edges of the cylinders (Figure 9-20).

9.9.4 The dust caps are removed from the end of the hydraulic lines attached to the spreader jacks and the lines are connected to the hydraulic manifold. The valves are opened after connecting the hydraulic line into the system. The jacks are kept covered with a vinyl bag (Figure 9-21).

9.9.5 The height of the circumferential sizing tools is checked. The top edge of Cylinder 2 must be no more than 1/16-inch below the center line of the circumferential sizing tool. The height of the sizing tool is adjusted if required by means of the adjusting wingnut (L). A bubble level is placed on top of the circumferential sizing tool and the tool leveled by means of the thumb nut on the support (K) (Figure 9-19).

CAUTION

Do not contact the cleaned surfaces of the cylinders while leveling the circumferential sizing tool.

9.9.6 The hydraulic system is pressurized to 3000 psig to expand the circumferential sizing tool, following the instructions displayed on the hydraulic console.

9.9.7 When the circumferential sizing tools are pressurized, two men can walk on the walkway of the spreader bar (8EH-0226). This enables them to enter and leave the tank using the bosun's chair. Completion of this operation should occur near a shift change. The joint is covered with aluminum foil inboard and outboard. Only approved tape is used and care is taken not to contaminate the joint. The men are removed from inside the tank and the tank secured until the next shift.

9.9.8 At the beginning of the next shift a tank entry crew is formed, a new permit is prepared, an oxygen check made, the crew is briefed, and emergency instructions are given to them. This operation is supported by the riggers, a move conductor, and a fireman. An in-tank crew of five or six men enter the tank, using the bosun's chair.

9.10 FINAL WELD PREPARATION

9.10.1 The aluminum foil is removed from the weld joint and the joint is prepared as defined in Section 1.12. This and subsequent operations must be accomplished with all personnel wearing clean white smocks, caps, and nylon gloves.

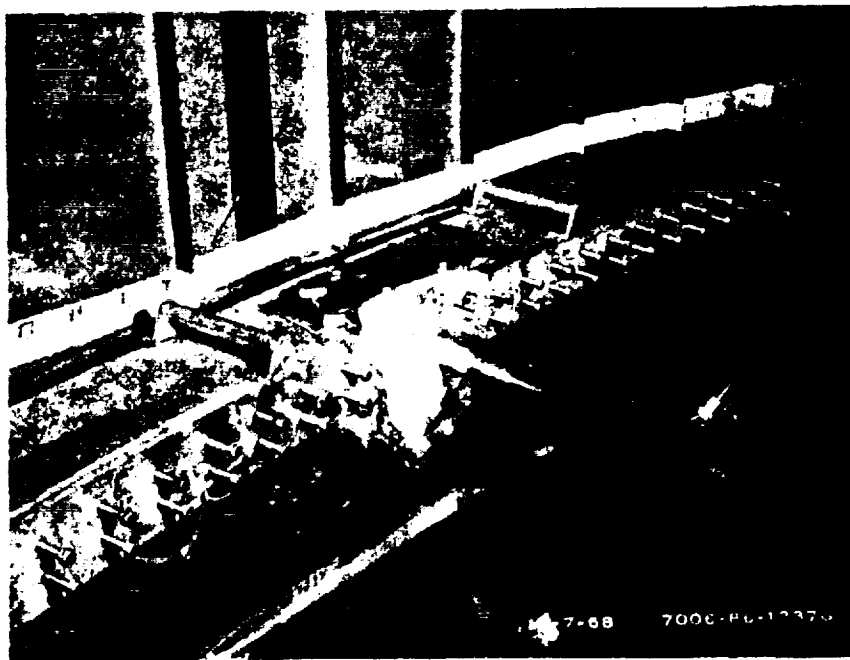


Figure 9-20. Spreader Jack Installation
(Showing Offset Adjustment Screws)

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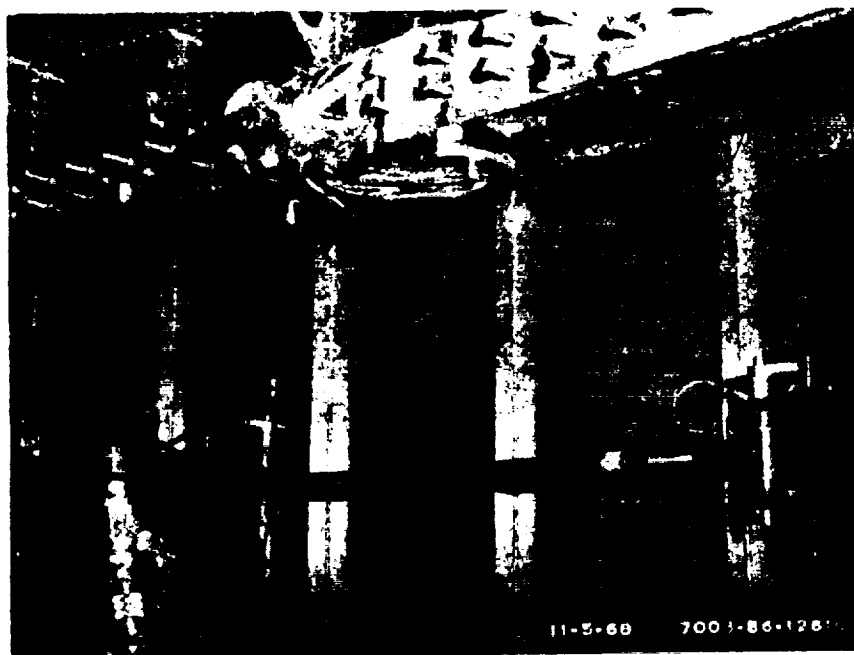


Figure 9-21. Spreader Jack Wrapped in Vinyl



9.10.2 The rotational alignment tool (T-7203718) is installed after the final cleaning operation. The alignment tool attaches to two of the tunnel left-hand attachment holes in Cylinder 2 and two of the left-hand holes in Cylinder 3. The tool is provided with bushings with a 1/4-inch inside diameter and a 3/4-inch outside diameter (Figure 9-22). Special screws, 1/4-28, are provided with the tool. These screws are installed through the bushings, which are slipped into the holes of the alignment tool. One of these holes in each half of the tool is slotted to allow for vertical tolerance between the tunnel attachment holes (Figure 9-23).

9.10.3 The circumferential sizing tool pressure is lowered to 500 psig. Precleaned 0.040-inch stainless steel shims are installed at 12 equally spaced points around the circumference of Cylinder 2. The spacers are taped to Cylinder 2 below the cleaned area with Mylar tape. One leg of the shim, approximately 1/2- to 3/4-inch long, must rest on the Cylinder 2 butt edge (Figure 9-24). These shims are used to prevent Cylinder 3 from bearing on Cylinder 2 during the lowering and rotational alignment operations.

CAUTION

Shims are cleaned with acetone prior to installing. Do not contaminate the shims during installation. Use only approved tape on the cylinder surface.

9.10.4 The crane and hydroset are used to start lowering the cylinder. Up-and-down pressure is applied manually to maintain a near-constant gap. The lowering operation is monitored from the outboard side of the cylinders. The rotational alignment is checked as the cylinder is lowered.

9.10.5 The Cylinder 3 assembly is lowered until there is approximately a 1/8-inch gap around the circumference. Rotational alignment is checked by means of the pointer on the upper alignment tool against the scale on the lower tool. The tolerance must be kept within 0.030 inch. The circumferential sizing tool pressure can be lowered below 500 psi, but care must be exercised that the upper cylinder does not shift, causing the butts of the joint to bump together.

9.10.6 The circumferential sizing tool is pressurized to 500 psi if the pressure has been lowered for rotation. Cylinder 3 is lowered at Position I until the gap is approximately 0.040 inch and the rotational alignment is checked. The circumferential sizing tools are pressurized to 6000 psig.

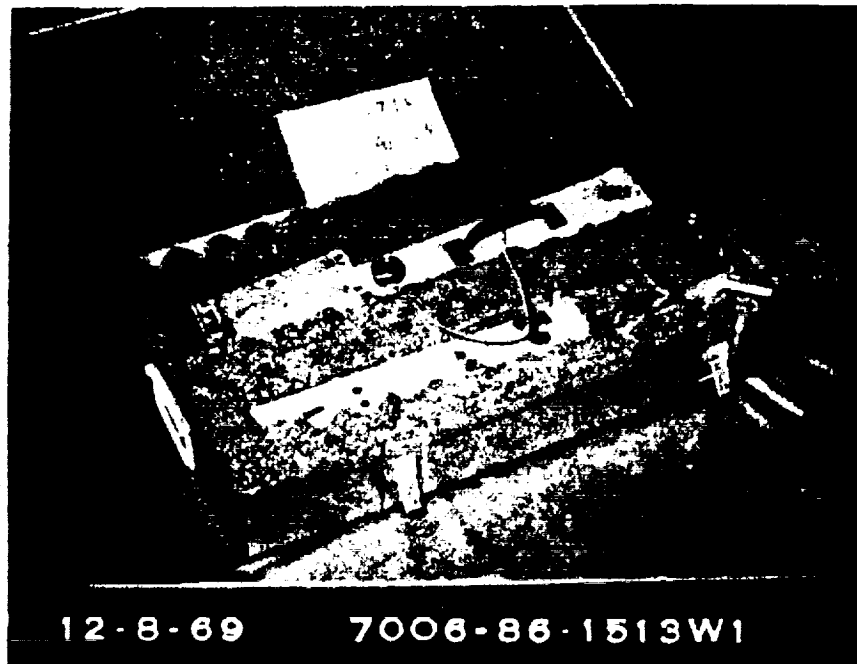


Figure 9-22. Alignment Tool

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Figure 9-23. Alignment Tool Installed

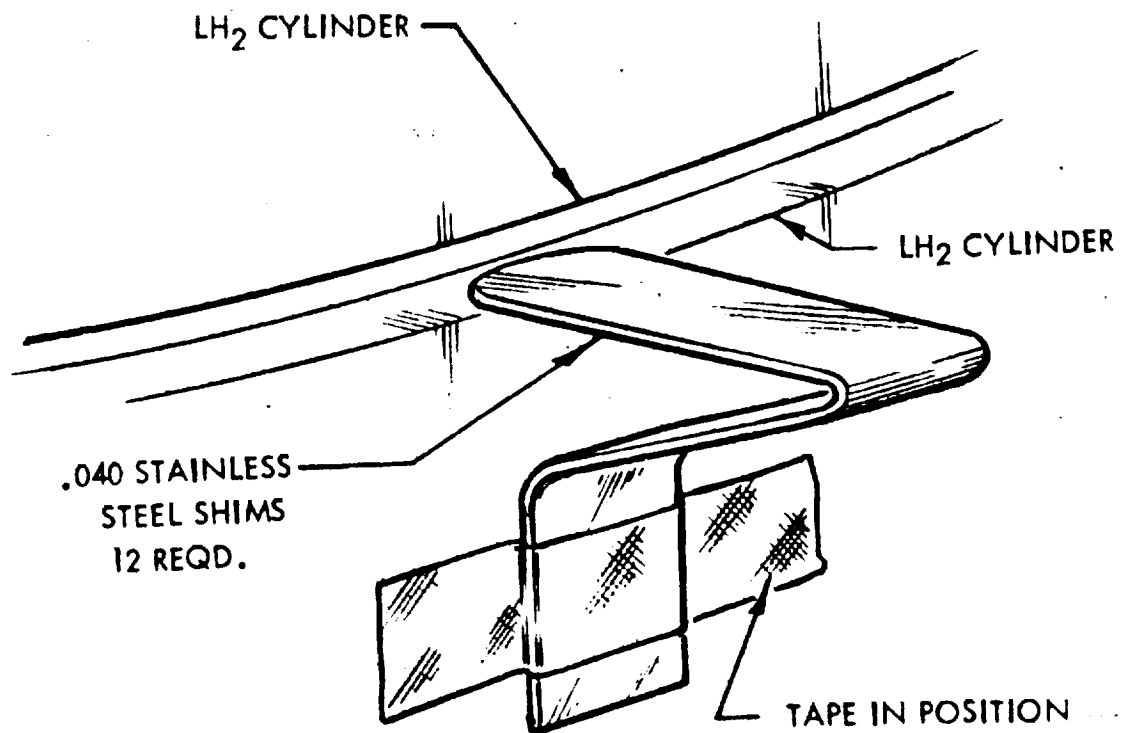


Figure 9-24. Stainless Steel Shim Installed



CAUTION

Only qualified personnel are to operate the hydraulic pump.

9.10.7 The rotational alignment is verified by inspection and the items are cleared in the FAIR book.

9.10.8 The stringer end protectors are removed from Cylinders 2 and 3. Approval to weld is verified in the FAIR book.

9.10.9 During the final cleaning operation, the welders and the weld engineers verify the equipment. The gas is checked for moisture content, the wire is checked, and the heat treat number, size, etc., are logged in the FAIR book. A bead-on verification plate is run by the welder and checked by Quality Control, which also checks the machine settings. The weld heads are then moved to the skate track at each weld position. The welder hooks the sensing and ground leads to the assembly and these are checked by the weld engineer.

9.11 WELD OPERATIONS

9.11.1 Two tack weld teams are utilized for the circumferential welds; each consists of a welder, an offset manipulator, and a vacuum hose operator outside the cylinder, and an offset manipulator inside. The teams operate approximately 180 degrees apart. Another team consisting of a man on the outboard side and a man on the inboard side for each weld station preset the offset ahead of the tacking crew. The weld machine parameters are set for the intermittent tack weld per the 971-D-00265 Weld Schedule.

9.11.2 Communication between the outboard and inboard side is by means of the intercom headsets (Figure 9-20). Using a 0.050-inch thick stainless steel gauge, the offset manipulator checks the offset and informs the man on the inboard side which cylinder must be moved to arrive at the target of 0.010-inch offset. The inside man adjusts the offset by means of the bolts on the inboard side of the sizing tools. The upper bolts control the upper fingers and the lower bolts control the lower fingers.

9.11.3 The first tack is located at approximately Position I where a 0.040-inch gap exists. The offset is set by the manipulating team. The joint area is vacuumed to remove any foreign material from the faces of the cylinders, with care taken not to touch the surfaces. The weld head is then moved into position for the first tack and locked to the gear racks on the



track. The torch is positioned for the tack, the circumferential sizing tool pressure of 6000 psi is verified, and the first tack is made per the 971-D-00265 Weld Schedule. A 3-inch long tack is run and the machine tapered out. A space of 6 inches is left between the first and second tack. The offset is checked and adjusted, the joint vacuum cleaned, and the second tack is run. This sequence is followed for 4 or 5 tacks. The rotational alignment tools and the 0.040-inch stainless steel shims are removed. The gap around the cylinders is checked, and if the gap 180 degrees from the first tacks exceeds 0.040 inch, an area near this point with less than 0.040-inch gap is used to start the tack operation of the second tack weld team. The same offset alignment procedure is used.

9.11.4 The two weld teams work progressively, tack-welding the cylinders with 3-inch long tacks at 9-inch centers. Each team will weld approximately one half of the circumference. The offset after tacking is checked by Quality Control and logged on an ITI form. Any tack which exceeds 0.015-inch offset after welding is checked by supervision for reworking.

9.11.5 After the tacking operations are complete, the circumferential sizing tool centering is checked. The pressure is dropped and the tools recentered on the weld joint if required. It is then repressurized to 6000 psig. All adjusting screws are backed off, then readjusted finger-tight to assure contact of the circumferential sizing tool with the cylinders.

CAUTION

Do not over-tighten screws.

9.11.6 The weld machine parameters are checked and reset for the continuous tack pass per the 971-D-00265 Weld Schedule. The two weld machines are moved so they are 180 degrees apart and in position so that each of the cables will reach around the 180 degrees to be welded. An air motor with a 1/4-inch ball rotary file is set up at each weld area. This is to be used to grind out the minute crater cracks which are left when the weld machine sequences out after running the continuous tack pass.

9.11.7 The continuous tack pass is run with each machine overlapping the start of the other machine for a minimum distance of 6 inches or until a good tie-in is made. As each machine sequences out for any reason, the tailout crater is ground out to a depth of approximately 0.060 inch with the ball rotary file. The crater is to be ground out as soon as the welding arc is terminated so that any small cracks will not propagate.



9.11.8 As the cover tack pass cools down, the circumferential sizing tools are again checked for centering and adjusted. If the tools are moved, they are repressurized to 6000 psi.

9.11.9 The entire cover tack pass is brushed with a clean fine stainless steel rotary brush in an air motor. The brush is moved in long strokes in one direction only. The dust and soot are vacuumed from the area. Care is taken not to touch the surface of the weld land with any material except the wire brush.

9.11.10 The two weld machines are moved back into the start position of the continuous tack pass. The weld machines are reset to the penetration parameters per the 971-D-00265 Weld Schedule and verified by inspection. The current override control is moved to the inside of the cylinder and the control switch on the weld pack turned on. The following are checked and verified for the penetration pass:

- a. Phone communications between inboard and outboard at each weld station.
- b. Circumferential sizing tool pressure and centering.
- c. Positioning of operators on the inboard side and contact with the welders on the outboard side by means of the phones.
- d. Availability of an air motor with 1/4-inch ball rotary file at each area.

9.11.11 The operator on the inboard side controls the amount of drop-through on the penetration pass and also is responsible for tracking the seam. The drop-through is watched by means of sight holes in the circumferential sizing tools. The penetration pass is run. Each machine will overlap the penetration of the other machine a minimum of 3 inches to assure an adequate tie-in. As each machine is sequenced out, the tailout crater is ground out to a depth of approximately 0.060 inch. Each tailout crater is checked to assure that all defects are removed.

9.11.12 The drop-through on the inboard side is checked for incomplete penetration. If any defective areas exist the weld machine for that area is moved into position and the optional penetration pass run per the 971-D-00265 Weld Schedule.

9.11.13 The air blower on the second floor is turned on to supply fresh air into the tank after completion of the penetration pass.



9.11.14 White garments are not required for the following operations. After the penetration pass or pickup operations are complete, the circumferential sizing tool pressure is dropped. The stringer protectors are reinstalled on the stringer ends of Cylinders 2 and 3. The spreader bar (8EH-0226) is removed and the personnel chute (8EH-0035) is installed. This enables using the tank entry basket (8EH-0760) in place of the bosun's chair per MHP-E-92-SII. The 8 spreader jacks and circumferential sizing tools are removed and stored neatly on the inboard side of the cylinder.

CAUTION

Do not remove the lower chucks.

9.11.15 The drop-through side of the weld is inspected for undercut, incomplete penetration, folds, etc., per Specification MA0107-016. Inspection will verify the drop-through, usually by means of a reference squawk.

9.11.16 The weld bead on the inboard side is milled to a height of 0.010 to 0.015 inch utilizing three or four weld shavers. Do not cut into the parent metal with the shavers.

9.11.17 The inboard side of the weld is abraded using a Bear-TeX wheel in an air motor. Long, even pressure strokes are used in abrading with no pauses in any one area, which causes high or low spots. Do not run Bear-TeX wheels crosswise or at angles to the weld. A fine stainless steel rotary brush is used to remove the soot from the outside of the weld. The penetration pass (outboard) is checked for any folds, etc., which can be blended out with a ball rotary file prior to X ray. The inboard and outboard sides are washed using clean cheesecloth and acetone.

9.11.18 When the inboard weld bead is milled, the Manufacturing in-tank crew leaves the tank and the Quality Control crew enters to set up and remove the X-ray film. Manufacturing, along with other supporting functions, continue to support the tank entry operation.

9.11.19 The penetration pass of the weld is X-rayed and the report prepared. Any defects identified are evaluated by the Manufacturing supervisor and weld engineer to determine which should be reworked prior to putting the cover passes on the weld. A Manufacturing Request for Rework (Form 0121-S) is filed requesting planning tickets for in-process rework.



9.11.20 The defective areas are reworked per the procedures outlined in Section 10. When the X ray and any rework is complete, the circumferential sizing tools are reinstalled as previously defined.

CAUTION

The following are white garment operations on outboard only. Using a clean fine stainless steel rotary brush in an air motor, wire brush the outboard side of the weld. Use long strokes in one direction only.

9.11.21 The parameters on the weld packs are reset for the cover pass weld per the 971-D-00265 Weld Schedule. The override control is to remain off.

9.11.22 The stringer end protectors are removed from Cylinders 2 and 3. The circumferential sizing tool pressure is rechecked and the air motors with a 1/4-inch ball rotary file are brought into each area. The two weld machines are moved back into the start position.

9.11.23 The first cover pass is run and the operator makes sure that the bottom edge of the penetration pass is covered by the first cover pass. The beginning of the cover passes is overlapped at least 6 inches before sequencing out.

9.11.24 The sequencing-out craters are ground out with a ball rotary file. The cover pass is wire brushed and the entire circumference inspected for lack of fill areas. Determination is made at this time whether to run a complete second cover pass or intermittent pickups.

9.11.25 The second cover pass, if required, is run as defined for the first cover pass. If intermittent pickups are required, the weld machine is moved to each area and the operation performed. After the second cover pass or intermittent pickups are made, the weld is inspected for defects.

9.11.26 The spreader jacks and circumferential sizing tools are removed and stored neatly on the inboard side of the cylinders.

9.11.27 The cover passes are milled from 0.010- to 0.015-inch height using 3 or 4 weld shavers. Do not touch the parent material. The milled weld bead is abraded with a Bear-Tex wheel in long, even strokes. Do not abrade across the bead (Figure 9-25).



Figure 9-25. Abrading Weld Bead With Bear-Tex Wheel

9.12 POST-WELD OPERATIONS

9.12.1 The weld is X-rayed and fluorescent-penetrant inspected. X-ray technicians X-ray the entire weld. The film is read out and triangulation shots made of any questionable areas. Rework is accomplished by the in-process method or by MR action per Section 10. After X ray is complete, fluorescent penetrant is used to inspect the joint both inboard and outboard. Manufacturing personnel blend out the defects if they do not lie below the parent material thickness. After the X-ray and fluorescent-penetrant inspections are completed, inspection verifies the sequences in the FAIR book.

9.12.2 The inboard and outboard sides of the weld are Chem-filmed by certified operators using the following operation per Specification MA0610-002:

- a. Using rubber gloves the weld land is wiped with acetone on a cheesecloth pad.



- b. The area is deoxidized abrasively by using a Bear-Tex pad rubbed lightly by hand.
- c. A dry cheesecloth pad is used to wipe the area dry.
- d. Using rubber gloves and a cheesecloth pad, the Chem-film solution is applied.
- e. After 3 to 5 minutes, excess solution is removed using cheesecloth pad and deionized water.
- f. After the Chem-film has dried for a minimum of 12 hours, a black vinyl corrosion tape is applied.



10.0 WELD REPAIR TECHNIQUES

10.1 SUPPLEMENTAL WELD PASSES

10.1.1 Defects that occur during welding are detected generally by visual inspection and can be reworked during primary welding operations. Rework for these defects are covered by procedures in the 971-D Weld Schedule for a specific weld joint. Internal discontinuities can be detected only by X ray and are covered by a rework procedure.

10.1.2 Reference documents applicable to this procedure are as follows:

MQ0501-007	Inspection, Radiographic
MQ0501-004	Inspection, Fluorescent

10.2 DEFECT CONDITIONS

10.2.1 The types of defect conditions that occur during the welding processes include the following:

- a. Incomplete Penetration - When the penetration pass is completed on a weld, the drop-through side is inspected. If any area has insufficient penetration that exceeds the weld specification, it is reworked. To rework an area of incomplete penetration, the weld skate is positioned approximately 3 inches ahead of the area and another penetration pass is made. The weld is tailed-out approximately 3 inches beyond the area. In some cases, if the supervisor and weld engineer feel that local shrinking might occur, the rework pass is lengthened.
- b. Off-Center Nugget - An off-center nugget can be reworked in the same manner as the incomplete penetration defect. However, the torch must be centered on the joint or must favor the side of the joint that has insufficient drop-through.
- c. Lack of Fill - Lack of fill occurs during the cover pass weld when the cover pass is run off-center. Lack of fill also can result if the groove left by the penetration pass is wide or deep. The rework procedure called out the 971-D Weld Schedule is simple. The weld skate is positioned approximately 3 inches ahead of the lack-of-fill area and another fill pass is made to pick up the discrepant area. The weld is then sequenced out 3 inches beyond the area.



- d. Undercut - The undercut condition is similar to lack of fill and is reworked in the same manner.
- e. Suckback - Suckback occurs on the drop-through side. Reworking requires use of a repair track mounted on the inboard side. The applicable 971-D schedule calls for a supplemental weld pass to be run using filler wire to fill the suckback area. If the suckback has folds in it, they are blended out through the use of a small ball rotary file prior to welding.

CAUTION

Prior to any rework weld pass, the area is cleaned by brushing with a clean stainless-steel wire brush.

10.2.2 All supplemental weld passes (whether for incomplete penetration, off-center nugget, lack of fill, undercut, or suckback) are documented on an In-Process Rework Request (Form 0121-S, Figure 10-1). Listed on the form are the area in inches from zero, the type of discrepancy, and the type of rework. This form is logged in the FAIR book and is signed by Manufacturing supervision, by a Material and Processes laboratory representative, and by Quality Control.

10.3 INTERNAL DISCONTINUITY DOCUMENTATION

10.3.1 Internal discontinuity defects are repaired after the penetration pass, completed melt pass, or after hydrostatic testing. These discontinuities may be porosity, inclusion, or crater cracks. They may be detected by visual inspection, X-ray, or fluorescent inspection.

10.3.2 Internal discontinuity defects are reworked with automatic equipment. In extreme cases a hand-fill may be used; however, this is usually followed by automatic machine passes over the hand-fill.

10.3.3 Qualified personnel inspect the weld head, read out the X rays, and issue a report on any discrepancy exceeding that allowed in Specification MQ0501-007. The defects are then X-rayed again by a triangulation method to determine the depth of the defect below the surface of the material.

10.3.4 Defects found in a completed weld or in a weld submitted to Quality Control for final approval can be reworked only by Material Review (MR) action. In these cases a squawk is written and submitted to MR for action. If the defect is accepted by MR Engineering, the MR acceptance is logged in the FAIR book and the squawk cleared. If it is not accepted, MR Engineering



MACHINE FUSION WELDING

Figure 10-1. In-Process Rework Request Form



indicates repair action. Planning tickets are issued for the repair, and when these are approved, the squawk is cleared.

10.3.5 Defects found after the penetration pass or cover passes and prior to submittal to Quality Control can be worked by an in-process procedure. In this case the out-of-specification areas are logged by the X-ray reader. Manufacturing supervision and the weld engineer determine which defects fall into the in-process range. Any other defects which are borderline and which supervision feels should be reworked are evaluated by Engineering and the weld laboratory.

10.3.6 The X-ray views containing the defective areas are then logged on an In-Process Rework Request (Form 0121-S). The form lists the views, type, and size of defect, location, whether inboard or outboard, and the recommended rework. A second section of the form also lists any supplemental passes made during the primary weld, such as incomplete penetration or lack of fill.

10.4 DEFECT REMOVAL

10.4.1 X-ray techniques pinpoint the defects by using a template made from the X-ray film.

10.4.2 A Zephyr mill with a 60-degree included angle cutter is used to make a 0.010-inch groove over the pinpointed area. If the groove-out is short, the mill can be held by hand. Long grooves are made with the mill positioned on an angle plate attached to a tooling skate. The height of the mill can then be adjusted to center the cutter over the defect. The skate is then power-driven for long grooves or moved by hand (Figure 10-2).

10.4.3 The 0.010-inch groove is X-rayed to verify location for height and length of the groove-out. Manufacturing supervision and the weld engineer verify that the groove is over the defect before further grooving.

10.4.4 Using the Zephyr cutter, the groove is enlarged to a depth of 30 percent of the material thickness. If the pores are open to the surface, they are removed by grooving deeper or using a ball rotary file to clean them out. A depth of 60 percent of material thickness must not be exceeded while attempting to remove defects.

10.4.5 If the pores are open to the groove surface at 60 percent, they may be locally blended out with a ball grinder. In the event that blending-out of these pores reduces the remaining material thickness below safe levels (as determined by Manufacturing supervision, the weld engineer, and a Materials and Processes laboratory representative), the groove-out must be submitted to MR for a disposition to add a hand-fill pass in the groove prior to machine welding.



Figure 10-2. Use of Grooving Mill

10.4.6 If a groove is acceptable to X ray at a depth of 60 percent or less, it can be prepared for welding.

10.4.7 Prior to welding, the ends of the groove are tapered out to accepted standards (see Figure 10-3).

10.4.8 As soon as the groove configuration is known, three grooves simulating the exact configuration are made in a test plate (Figure 10-4). The test plate is clamped to the skate track by means of suitable clamps. The weld head is set up and tracked through the grooves. Attention is given to the wire feed nozzle position. The machine settings are set according to the applicable 971-D Weld Schedule. A pass is made through the groove-outs in the test plate and checked for the following:

- a. Sufficient heat to assure good wetting action in the bottom of the groove on the first weld pass
- b. Sufficient heat without suckback on the back side; penetration of the material is permissible and desirable in some instances
- c. Adequate filler wire speed and control

10.4.9 If the test welds are acceptable to Manufacturing supervision, the weld engineer, and a Materials and Processes laboratory representative, the production part can be welded.

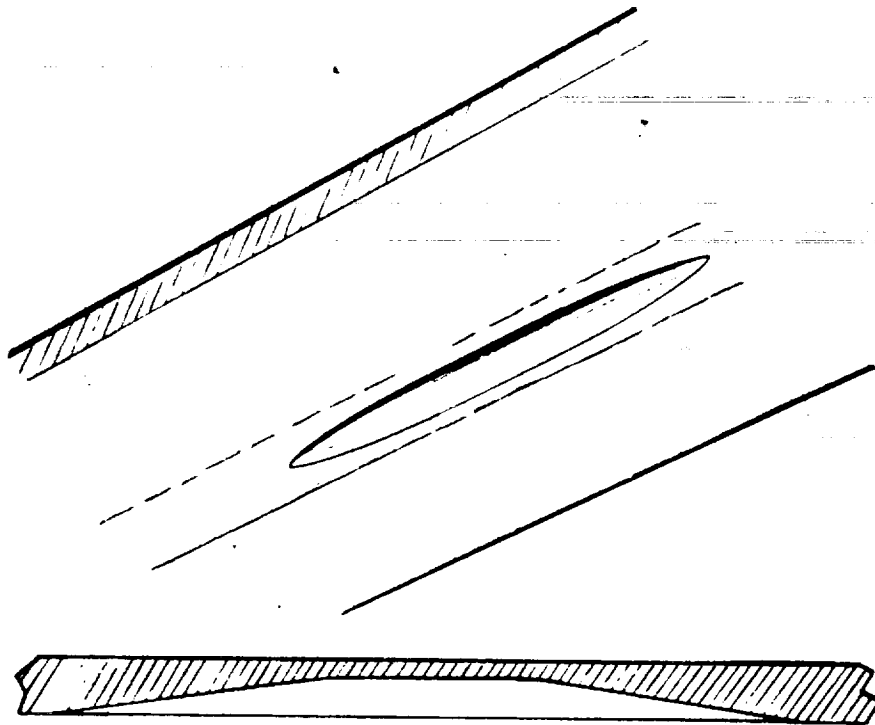


Figure 10-3. Groove-out Configuration

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best available copy.

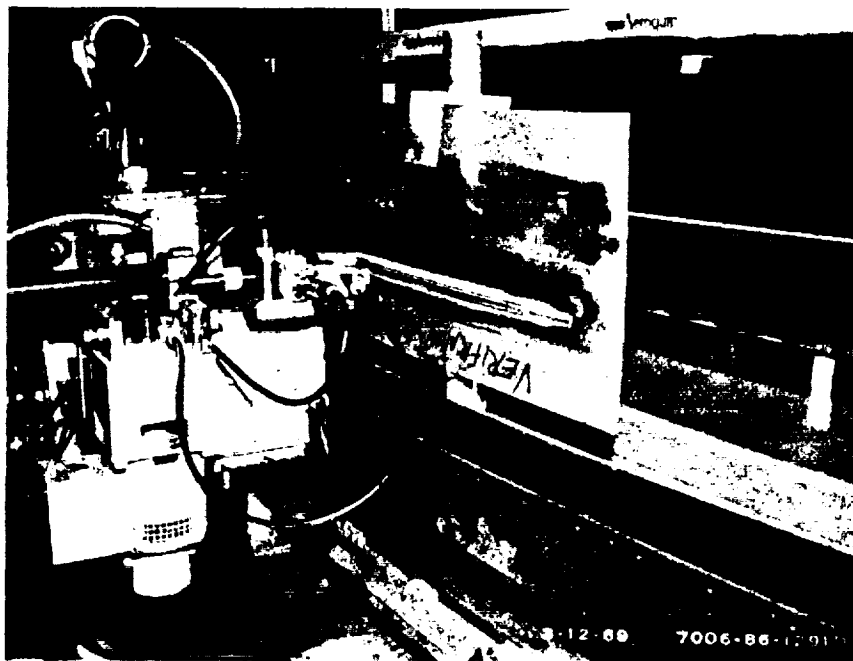


Figure 10-4. Verification Plate



10.5 WELDING

10.5.1 The test plate is removed and stored. The weld head is set up at the groove-out on the vehicle. The run-in and run-out of the groove are checked by making a dry run through the groove with the torch. The clearance of the wire feed is checked during the run.

10.5.2 If the groove is satisfactory, it is polished with an abrasive wheel. The entire rework area is wiped with clean cheesecloth dampened with acetone. The cloth is turned frequently as the groove is wiped. The rework area is brushed with a fine stainless-steel rotary brush. The brush is moved in straight strokes in one direction only. A fine stainless steel hand brush can be used as a substitute for the rotary brush.

CAUTION

Do Not brush crosswise to the groove.

10.5.3 The weld head is positioned approximately 2 inches ahead of the groove. A check is made of the ground sensing lead hookup, gas supply and flow, the weld parameters, tungsten configuration and projection of torch cup, skate speed, and wire setting and supply.

10.5.4 During the test-plate verification and groove-cleaning preparation, the backup bar beam is positioned. The first weld pass is run starting 2 inches ahead of the groove-out and the sequence-out is started 2 inches past the groove.

10.5.5 A 1/4-inch ball rotary file chucked in an air motor is used to grind out the tail-out crater to a depth of 0.050 to 0.060 inch. This is to be accomplished as soon as the arc is extinguished. If this is not done immediately, the crater cracks may propagate.

10.5.6 The pressure on the clamp fingers must be released so that an X-ray film can be placed over the rework area. Any folds or visual defects on the surface of the first weld pass are blended out using a 1/8-inch-diameter rotary file or other suitable cutter. The original depth of the groove-out will not be exceeded when cleaning up the first weld pass.

10.5.7 The first weld pass is X-rayed.

10.5.8 While the X-ray is being developed and read out, the groove-out is wire-brushed, the weld head is set up, and the next pass is prepared. If the X ray is acceptable, the rework is wire-brushed with a clean stainless-steel rotary or hand brush.



10.5.9 The second fill pass is run. The weld is started at least 1 inch ahead of the previous pass and the tailout is at least 1 inch beyond the previous pass.

CAUTION

All succeeding weld passes must overlap the previous pass. Start or stop of any weldments must not be made at the same point.

10.5.10 The tailout cracks are ground out and the weld is again submitted to X ray.

10.5.11 The fill passes are continued, and each pass is overlapped, with X rays made after each pass until the groove is filled.

10.5.12 The FAIR book is cleared of entries after each pass is made. The depth of the groove, number of passes, start and stop areas in inches, and X-ray approval must be cleared before proceeding.

10.5.13 The final pass is X-rayed and a fluorescent inspection is performed on the entire rework area, both inboard and outboard. The FAIR book is cleared. The final X-ray and fluorescent inspections must be approved by inspection. If the rework was accomplished by MR action, the MR acceptance also must be cleared in the FAIR book.

10.5.14 When defects occur in a fill pass as shown on the X rays, that pass can be removed wholly or partially by grinding. The depth of grinding must not exceed the amount of the fill pass being removed. If defects exceeding the specification cannot be removed by grinding out a pass, the rework must be terminated and the area submitted to MR for further action.

10.5.15 Any defects exceeding the specification and remaining after the initial 60-percent groove-out, and which still remain after filling the groove, must be removed from the opposite side. This must be accomplished through MR action, which authorizes back-to-back repair. In that case the procedure for reworking the opposite side is the same as that for an initial repair.

10.5.16 A rework of the inboard side requires the use of a short skate track (T-7201010) supported by vacuum chucks. This track can be adjusted for various conditions and can be readily moved from area to area. Use of the inboard track requires that the weld head and pendant station be moved to the inboard side.



10.5.17 A verification plate is run after the weld head is positioned on the inboard side prior to any repair action. This is to verify the operation of the equipment after it is torn down and reassembled.

10.5.18 The groove-out and reweld procedure is the same as that for the outboard repair.

10.5.19 On a back-to-back repair, caution must be exercised so that the start and stop areas of the inboard passes do not coincide with those on the outboard side. They must be staggered. This can be accomplished by checking the X-ray views as the rework or repair progresses.

10.6 POST-WELD OPERATIONS

10.6.1 All in-process rework or repair action must meet the specification allowables for X-ray and fluorescent inspections.

10.6.2 After each repair is made, final X-ray shots are taken. Views are shot straight in at the area and from two angles (triangulation). This is done to pick up possible inclusions or cracks that could not be detected on a film shot in one plane only. If the X-ray is acceptable to inspection, the FAIR book is cleared.

10.6.3 Fluorescent inspection is performed on the inboard and outboard side of all reworked areas. The inspected area must encompass the start and stop areas to detect any minute tailout cracks that X rays do not detect. If the fluorescent penetrant inspection meets the specification allowables, inspection clears the FAIR book.

10.6.4 If either or both the X-ray and fluorescent inspections pick up defects that are out of specification, the areas are submitted to MR for further disposition.

10.7 USE OF WELD HEAD TOOL (T-7201010)

10.7.1 This tool (T-7201010) is a weld head used primarily for repair work after pneumostatic testing. It consists of a weld torch mounted on a powered base. The travel speed of the torch can be controlled precisely. The base of the torch is supported by vacuum chucks and, because of its compact size, is very mobile.

10.7.2 Defects detected on the inboard or outboard side, whether in a horizontal or vertical weld, can be repaired with this tool. Repair work after pneumostatic inspection is accomplished with the stage in a horizontal position on a transporter.



10.7.3 When a repair is required on the outboard side, a work platform (8EH-5129) positions a repair crew at the horizontal centerline of the stage. This allows the repairs to be performed on a horizontal plane for the vertical welds of the stage and on a vertical plane for the circumferential welds.

10.7.4 A piece of aluminum sheet 0.064 to 0.125 inch is taped to the insulation protective covers to provide a base for the vacuum chucks of the weld head. The plate is held by Permacel Tuck tape or equivalent.

10.7.5 The weld head is positioned to the plate, and vacuum is applied to the chucks. The base parallel is aligned carefully to the weld being repaired.

10.7.6 A safety line is attached to the base of the weld head and to a suitable support. This line is used to prevent accidental dropping of the weld head in the event of vacuum failure. During welding, the weld head base is held manually to the sidewall of the tank as an added safety measure.

10.7.7 When the correct position of the head is determined, it is removed from the stage and vacuumed to a test plate clamped to the work stand. The ground and sensing leads are clamped to the test plate, the correct parameters according to the 971-D Weld Schedule are verified, and the filler wire type and shielding gas amount and flow are verified prior to welding.



APPENDIX A

GLOSSARY

Term	Description
BOSUN'S CHAIR	A swing-type seat attached to the over-head crane and used to lower personnel inside the tank while performing preweld operations.
BULKHEAD	A half-sphere partition separating one compartment from another. On the Saturn S-II Program, a bulkhead is defined as the semi-spherical structure which forms one of the ends of a tank. Three bulkheads are used on S-II tanks: the forward bulkhead on the LH ₂ tank, the common bulkhead which is both the lower bulkhead of the LH ₂ tank and the upper bulkhead of the LO ₂ tank, and the lower LO ₂ bulkhead.
CHIP GUARDS	Used on top of the frames on the inboard side of the vehicle to prevent chips and shavings from falling down on the assembly during the trim, filing, and milling operations.
CHIP TROUGHS	Mounted on the outboard side of the vehicle to prevent chips from falling into clamps, gears, tracks, etc.; attached by a woven belt.
CIRCUMFERENTIAL SIZING TOOL	Aluminum bars composed of eight segments contoured to 198-inch radius; on a circumferential weld, they are used as a sizing ring to hold the cylinder and bulkhead in proper contour and alignment for welding. They are expanded by hydraulic pressure to the desired diameter.



Term	Description
CIRCUMFERENTIAL WELD	1244 inches of tungsten inert gas welding that joins cylinder to cylinder or cylinder to bulkhead. It is made while the stage is in the vertical position by welding horizontally around the entire circumference.
CONTINUOUS TACK	A weld to increase stability of the weld joint by relieving the residual stresses induced by forming and by the previous intermittent tack welds. It permits the penetration pass to be performed with minimum joint movement. This can also be termed as a tooling aid.
CONTROL STATION	The control station is an area in Manufacturing set aside for the control of FAIR documents. FAIR books are checked out of the control station when an assembly is put in work and checked into the station when the assembly is completed.
CYLINDER	A 33-foot diameter ring. The S-II LH ₂ tank is composed of six cylinders. Five of them are 99 inches high and Cylinder 1 is 28 inches high.
GAP	The opening between the cylinder and the bulkhead or between cylinders (0.040 inch) that is allowable by Process Specification MA0107-016
GROUND CLAMPS	The method by which the welding machine is grounded to the production assembly to complete the electrical circuit; a vital part of the welding process. It is very important that the area be thoroughly cleaned prior to connecting the ground clamps.



Term	Description
HYDRAULIC SYSTEM	Includes the reservoir, hoses, spreader jacks, and attaching fittings. The system is used to put 6000 pounds of backup bar pressure to hold the cylinder and bulkhead in place during the welding operation.
INCOMPLETE PENETRATION	An attempted penetration pass which fails to fuse the base metal to a 100-percent depth.
INTERMITTENT TACK	Primarily used as a tooling aid to control offset and gap. Tacks are approximately 3 inches long and spaced at approximately 6-inch intervals. Depth of penetration is usually about 25 percent.
MANIFOLD SYSTEM	Includes the pressure pump, vacuum lines, and attachment fittings. It is used to pull a vacuum on the pads to secure the tooling against the side of the vehicle.
MOVE BOARD	A method used by production supervision to notify the Material Handling group that an assembly is ready to be moved from one area to another. On the board the supervisor enters the assembly, the station it is located in, the area it is to be moved to, and the anticipated time it should be moved to meet schedules.
PERSONNEL CHUTE	A work and entry platform that is placed over the LH ₂ bulkhead after the circumferential weld is completed.
PENETRATION WELD	That weld which induces 100-percent penetration or fusion of the weld melt into the base metal.
PERSONNEL CARRIER	An enclosed carrier (or cage) suspended from the overhead crane by which employees enter and are lowered into the tank through the LH ₂ bulkhead to the work area.



Term	Description
MYLAR TAPE	A tape that has been approved for use on the S-II stage to prevent oxidation and to mark locations during fabrication; it must be removed when it has served its purpose.
PI-TAPE	An instrument (special steel tape) used to measure the circumference of bulkheads and cylinders. It is marked in increments of 0.049 of an inch and can be read to approximately 0.010 of an inch. Personnel must be certified in use of this tool.
602 PRIMER	A coating bonded to the surface of the cylinder and the bulkhead to prevent corrosion or prepare for bonding. It also serves to protect the surface during fabrication. Care should be exercised when working near the 602 primer to prevent scratches.
ROTATING TURNTABLE	A tool which holds an assembly in a vertical position and rotates it past the fixed weld heads to complete the circumferential weld.
SADDLES	Manufacturing aids used to support the LH ₂ bulkhead on top of Cylinder 6 during preweld station preparations. They are shaped in a "H" to allow the cylinder and bulkhead to slip into the upper and lower slots.
SAFETY BLOCKS	Pieces of aluminum that are slipped between the two assemblies when one is raised to prevent possible damage to the stage or personnel. There are four blocks and they are attached at the crossover welds.



Term	Description
SAFETY POST	Pieces of tooling that are placed between the turntable and the lower chucks to prevent the chucks from falling if vacuum is lost.
SHIMS	Pieces of 0.040-inch stainless steel formed to fit over the upper edge of the cylinder to hold the faying surfaces of the two assemblies apart during setup and to prevent chafing and contamination.
SYSTEMS TUNNEL	A structure that extends from top to bottom of the LH ₂ tank. This area is strengthened by heavier stringers and requires different vertical splices. Its purpose is to house the fill and drain lines and electrical wiring.
TANK ENTRY CERTIFICATION	A physical examination to determine an employee's fitness to work inside an enclosed area. Required for personnel working inside either the LH ₂ or LO ₂ tanks. This examination is advisable for safety and health reasons.
TEFLON PADS	Attached to the turntable and used to support the assembly. The supports are coated with Teflon to prevent damage to the aluminum, and are adjustable up and down to allow leveling of the assembly.
T-BAR	A threaded jack with a leveling bar on top. T-bars are fastened to the lower vacuum chucks to support the backup bars in a level plane during trimming and welding operations.
TEFLON SCREWS	Used for adjustment of the assembly inboard and outboard to assure proper placement on the turntable. The screws are coated with Teflon to prevent damage to the assembly.



Term	Description
WELD LANDS	A thickened area between the rib ends that is left free of stringers to allow accessibility for welding. This area is approximately 3 inches on any edge of a panel, cylinder, or bulkhead that is to be welded.
VACUUM CHUCKS	In circumferential welding, used on the inboard side of the vehicle to support the backup bars and the jacks to raise and lower the bulkhead. They are composed of eight segments with 12 vacuum pads on each segment, and attach to the inside of the vehicle by vacuum.
VERIFICATION PLATES	Plates prepared by Manufacturing to proof-test the weld machines before welding on production assemblies. They are required by Process Specification MA0107-016.



APPENDIX B

TOOLING LIST

The tooling used for the circumferential welding described in this volume is as follows:

Tool No.	Function	Assembly
T-7200015-SPT	Support tool for circumferential trim and welding	LH ₂ Cylinder 1, Common and aft LO ₂ bulkheads
T-7200039-SPT	Skate track for trim and weld skates	LH ₂ cylinder final assembly
T-7200041-SPT	Circumferential trim tool	LH ₂ cylinders and LO ₂ tanks
T-7200211-SPT	Collapsible work platform positioned in LO ₂ bulkhead for making girth weld	LO ₂ bulkhead
T-7200515-SPT	Support tool for stage closeout weld	LH ₂ Cylinder 3 assembly to LH ₂ Cylinder 2
T-7200516-SPT	Support tool for circumferential trim and welding	LH ₂ cylinders LH ₂ forward bulkhead
T-7200691-SPT	Alignment and drill tool	LH ₂ forward skirt and Cylinder 6
T-7200753-SPT	Support tool for circumferential trim and welding	J section and Cylinder 1
T-7201010-SPT	Automatic repair tool for welds up to 6-1/2 inches long	Bulkheads and LH ₂ cylinder subassemblies
T-7201304-SPT	Skate tracks for the repair of circumferential welds	LH ₂ cylinders



Tool No.	Function	Assembly
T-7201983-SPT	Machine weld repair, fixture; groove out weld areas to prepare for weld	All bulkheads and LH ₂ cylinder areas
T-7204256-SPT	Weld pack units (Sciaky); weld power pack and skate assembly	LH ₂ bulkhead to LH ₂ Cylinder 6; Cylinder 3 to 4
T-7204259-SPT	Weld pack units (Sciaky); weld power pack and skate assembly	Cylinder 4 to Cylinder 5; Cylinder 1 to Cylinder 2
T-7201986-SPT	Weld pack units (Sciaky); weld power pack and skate assembly	Cylinder 5 to Cylinder 6; LO ₂ girth weld; Cylinder 2 to Cylinder 3/closeout
T-7201989-SPT		
T-7323001-SPT	Weld pack unit (Sciaky); spare	All cylinders and bulkheads
T-743935-SPT	Weld pack units (Sciaky); weld	J section to Cylinder 1
T-743936-SPT	power pack and skate assembly.	Common bulkhead
T-7202459-SPT	Protective mats used with T-7200211 work platform when making LO ₂ weld	Aft LO ₂ bulkhead
T-7203856-SPT	To check offset before and after weld operation of bulkhead tanks panels	LO ₂ , LH ₂ bulkhead tank assembly
T-7204176-SPT	Trim skate, contains Zephyr cutter for circumferential weld bead shaving	LH ₂ cylinders
T-7204210-SPT	Weld skate support	J section and Cylinder 1
T-7204211-SPT	Weld certification tool, holds test parts for welding	Bulkheads and cylinder assemblies



Tool No.	Function	Assembly
T-7204223-SPT	Sizing tool for circumferential welding	LH ₂ bulkhead to Cylinder 6 and LH ₂ cylinders
T-7204230-SPT	Skate track for inner circumferential weld repair tool	LH ₂ cylinder and assemblies
T-7204234-SPT	Collapsible work platform	Girth LO ₂ assembly
T-7204315	Offset tool to control offset off LO ₂ girth weld	Aft LO ₂ bulkhead
T-7204334-SPT	Trim tool for circumferential trimming	J section
T-7204383-SPT	Support fixture to locate and support the bulkhead and cylinder assemblies for final closeout weld	Cylinder 2 to Cylinder 3
T-7204464-SPT	Sizing tool for circumferential welding	LH ₂ cylinders
T-7204509-SPT	Trim skate for circumferential trimming	J section and Cylinder 1
T-7203718-SPT	Alignment tool for stage rotation alignment prior to circumferential welding	LH ₂ cylinders
T-7204282-SPT	Alignment tool for stage rotation alignment prior to circumferential welding	Bolting ring and Cylinder 1 to Cylinder 2



APPENDIX C

APPLICABLE SPECIFICATIONS

The following specifications are applicable to this volume:

MA0107-016	Machine Fusion Welding of Aluminum Alloys, Saturn S-II
MA0609-007	Corrosion Control of Aluminum Alloy Components, Saturn S-II
MA0610-002	Surface Preparation for Application of Chem-Film
MQ0501-007	Inspection, Radiographic
MQ0501-004	Inspection, Fluorescent
MQ701-004	Certification of Machine Fusion Welders



APPENDIX D

SUPPORTING DOCUMENTS

- MHP-A-07-S-II Position LH₂ Stack Assembly (3/4/5) onto Tool Fixture T-7200516, VAB
- MHP-A-08-S-II Position LH₂ Bulkhead/Cylinder 6 Assembly on Cylinder 3/4/5 Assembly on Tool Fixture T-7200516
- MHP-A-13-SII Position AFT LO₂ Bulkhead Onto T-7200015 Tool in VAB
- MHP-A-14-SII Position Common Bulkhead, Cylinder 1 and 2 onto LO₂ Bulkhead in T-7200015 Tool
- MHP-E-14-SII Assem/Install T-7200011 Work Platform in LO₂ Tank
- MHP-A-17-SII Lift Complete LO₂ Tank Onto Simulated Aft Skirt
- MHP-A-48-S-II Position Common Bulkhead in the Manufacturing Aid
- MHP-A-49-S-II Mate Cylinder 1/2 to the Common Bulkhead
- MHP-C-87-S-II Move LH₂ Cylinder From Storage to Station 1A Using Pneumogrip
- MHP-C-88-S-II Move LH₂ Cylinders from Storage to Station 1A
- MHP-C-76-S-II Install LH₂ Bulkhead on LH₂ Cylinder in Station 1A
- MHP-A-18-S-II Lift upper LH₂ Tank Assembly Onto LO₂ Tank Assembly
- MHP-E-20-S-II Install T-7204234 Wave Platform on Common Bulkhead



- MHP-E-92-S-II Position BEH-0035 Personnel Chute and/or
BEH-0760 Basket to LH₂ Tank VAB
- MHP-A-50-S-II Position LH₂ Cylinder Stack on Weld Tool
- MHP-A-51-S-II Position LH₂ Cylinder 2 on Cylinder 1 in Tooling
Fixture, Using the Pneumagrip
- MHP-A-52-S-II Position LH₂ Cylinder 2 on Cylinder 1 in Tooling
Fixture, Using the Pneumagrip
- MHP-A-53-S-II Remove LH₂ Cylinder 1 and 2 Assembly from
Tooling Fixture, Using the Pneumagrip
- MHP-C-66-S-II Move LH₂ Cylinder 1 from Storage to VAB
- MHP-C-89-S-II Move LH₂ Cylinder (2-6) Assemblies From
Weld Fixture T-7200001 to Storage/VAB/Weld
Station 1A Using Pneumagrip-5223 Adapters
- MHP-C-64-S-II Move LH₂ Cylinder 1 Assembly From Weld
Jig Fixture T-7200001 to Storage/Weld Station
in BFB

Reference documents applicable to this volume are as follows:

- | | |
|-----------|---|
| V7-300011 | Structure Assembly Complete |
| V7-333002 | LO ₂ Tank Assembly |
| V7-333102 | LO ₂ Tank - Common Bulkhead Assembly |
| V7-333202 | LO ₂ Tank - Aft Bulkhead Assembly |
| V7-332002 | LH ₂ Tank Assembly |
| V7-332542 | LH ₂ Lower Central Cylinder Assembly (No. 3) |
| V7-332442 | LH ₂ Upper Center Cylinder Assembly (No. 4) |
| V7-332141 | LH ₂ Bulkhead Assembly |
| V7-332242 | LH ₂ Tank Upper Cylinder Assembly (No. 6) |
| V7-332342 | LH ₂ Tank Upper Intermediate Cylinder |
| V7-332743 | Lower Cylinder 1/4 Panel Skin |
| V7-332744 | Lower Cylinder 1/4 Panel Skin |



V7-332745 Lower Cylinder 1/4 Panel Skin

V7-332742 LH₂ Tank Lower Cylinder

Tool Operation Sequences (TOS)

TOS-556-0005 Weld Backup Bar Circumferential Welding
TOS-556-0008 Turntable Circumferential Welding
TOS-556-0015 Work Platform - LH₂ Tank
TOS-556-0016 Internal Work Platform - LO₂ Tank
TOS-556-0017 Trim Skate - Circumferential Weld
TOS-556-0018 Trim Skate - J Weld
TOS-556-0023
TOS-556-0027 Offset Measuring Tool Circumferential Welding
TOS-556-0029
TOS-556-0036
TOS-556-0037
TOS-556-0038 Support Fixture - LO₂ Tank Subassembly
TOS-556-0039 Support Fixture - LO₂ Tank Subassembly

Weld Schedules

Form 971-D-00225 J Weld
Form 971-D-00237 Cylinder 1 to 2
Form 971-D-00265 Cylinder Welds - 2 to 3, 3 to 4, 4 to 5,
5 to 6, 6 to Forward LH₂ Bulkhead
Form 971-D-00550 LOX Girth Weld



PRO MW 565-011	Girth Weld Common Bulkhead to Aft LO ₂ Bulkhead
PRO MW 565-014	Circumferential Weld Cylinder No. 2 to Cylincer No. 3 Closeout Weld.
PRO MW 565-016	Circumferential Weld LH ₂ Bulkhead to Cylinder No. 6
PRO MW 565-017	Circumferential Weld Cylinder No. 1 to Cylinder No. 2
PRO MW 565-019	Circumferential Weld "J" on Common Bulkhead to Cylinder No. 1 and No. 2 Assembly
PRO MW 565-027	Circumferential Weld LH ₂ Bulkhead to Cylinder No. 6
PRO MW 565-028	Circumferential Weld Cylinder No. 5 to Cylinder No. 4
PRO MW 565-029	Circumferential Weld Cylinder No. 4 and No. 5 Assembly to Cylinder No. 3
PRO MW 565-010	Certification/Verification Test Welds
PRO M-081	Clean Prior to Weld